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VOLUME 112(2): AUGUST 2015

CONTENTS

EDITORIAL 53

MAPPING THE POTENTIAL DISTRIBUTION OF THE CRITICALLY ENDANGERED FOREST OWLET *HETEROGLAUX BLEWITTI* IN INDIA
Girish Jathar, Dharmaraj Patil, Mohit Kalra, Thilina de Silva, A. Townsend Peterson, Mohammed Irfan-Ullah, Asad R. Rahmani, Prachi Mehta and Jayant Kulkarni 55

DISTRIBUTION, ABUNDANCE, AND HABITAT SIGNATURE OF THE INDIAN GIANT FLYING SQUIRREL *PETAURISTA PHILIPPENSIS* (ELLIOT 1839) IN THE WESTERN GHATS, INDIA
Santhanakrishnan Babu, Honnavalli Nagaraj Kumara and Eluvathingal Antony Jayson 65

DIATOMS IN SUB-SURFACE SEDIMENT CORES FROM MANGROVE FOREST FLOORS OF DELTAIC ISLANDS IN SUNDARBANS, INDIA
Manjushree Mandal, Biswajit Biswas, Sanoyaz Sekh and Neera Sen Sarkar 72

NEW DESCRIPTION

A NEW SPECIES OF THE GENUS *LEMBA* HUANG, 1983 (ORTHOPTERA: ACRIDIDAE: OXYINAE) FROM THE STATE OF MEGHALAYA, NORTH-EAST INDIA
Mohd Imran Khan and Mohd Kamil Usmani 83

REVIEWS

1. NATURE WITHOUT BORDERS
Reviewed by Asad R. Rahmani 86

2. THE ANNOTATED MALAY ARCHIPELAGO
Reviewed by Asad R. Rahmani 87

SMITHSONIAN
FEB 01 2017
LIBRARIES

MISCELLANEOUS NOTES

MAMMALS

1. First record of the Himalayan Wolf *Canis himalayensis* from Baniya Kund, Kedarnath Wildlife Sanctuary, Uttarakhand, India
Nitin Bhardwaj and Sheila Castelino 88

2. Adoption of power transmission towers as night refuge by Grey Langur *Semnopithecus entellus*
Rohit Chakravarty, Shashank Dalvi and A.M.K. Bharos 88

3. Tubewell pits as death traps for animals: a case study in Alwar district, Rajasthan, India
Satish Kumar Sharma and Vijay Kumar Koli 89

AVES

4. First report of Black Baza *Aviceda leuphotes* from Vidarbha region, Maharashtra, India
Gajanan Bapat and J.S. Wadatkar 92

5. Sighting of a juvenile White-tailed Eagle at Jor Beed carcass dump, Bikaner, Rajasthan, India
Asif N. Khan 92

6. First breeding record of Saker Falcon *Falco cherrug milvipes* in India
Pankaj Chandan, Taej Mundkur, Jigmet Takpa, Pushpinder Singh Jamwal, Intesar Suhail, Tsewang Rigzin and Rohit Rattan 93

7. White-breasted Waterhen *Amaurornis phoenicurus* nesting on a tree
C. Gangadharan Menon 95

8. Sighting of Common Black-headed Gull *Chroicocephalus ridibundus* Linnaeus, and Wedge-tailed Shearwater *Ardenna pacifica* (Gmelin) from south Andaman, Andaman & Nicobar Is., India
C. Sivaperuman, P. Naveen Kumar and G. Gokulakrishnan 95

9. Observations on the breeding of the Brown Fish-owl *Ketupa zeylonensis* in Kerala, southern India
T.N. Bindu and Peroth Balakrishnan 97

10. Sighting of Grey Hypocolius *Hypocolius ampelinus* in Narara Marine National Park, Gujarat, India
Nosherwan Sethna and Kunal Munsiff 98

11. White-capped River-chat *Phoenicurus leucocephalus* (Vigors): first record for Jharkhand state, India
Anwaruddin Choudhury 99

12. Night roosting on iron poles by the White-naped Tit *Parus nuchalis* in Udaipur, Rajasthan, India
Satish Kumar Sharma 100

13. A new low elevation summer record of Blanford's or Crimson Rosefinch *Agraphospiza rubescens* (Blanford) from Sikkim, India
Anwaruddin Choudhury 101

14. Sap-drinking by birds on tapped Indian Date Palm *Phoenix sylvestris*
Vishal Rasal 102

REPTILES

15. The Mountain Pit Viper *Ovophis monticola* (Günther, 1864) (Reptilia: Crotalidae) in Mizoram, India, with a note on its peculiar behaviour in captivity
Daya Nand Harit 103

FISH

16. First report of McAdam's Scorpionfish *Parascorpaena mcadamsi* (Fowler, 1938) from Indian waters
Anil Mohapatra, Prasad Chandra Tudu and Dipanjan Ray 104

INSECTS

17. Hover-flies (Diptera: Syrphidae) in the Bombay Natural History Society Collection, with an annotated checklist of those recorded from Maharashtra, India
Kumar Ghorpadé 106

18. Range extension of Common Jay *Graphium doson* (Lepidoptera: Papilionidae) to Gujarat, India
B.M. Parasharya and Dhaval S. Patel 110

19. Additions to larval host plants of butterflies of the Western Ghats, Kerala, southern India (Rhopalocera, Lepidoptera): Part 2
Kalesh, S. and Satya Krishna Prakash 111

OTHER INVERTEBRATES

20. First record of *Stiliger smaragdinus* Baba, 1949 (Mollusca: Sacoglossa: Limapontiidae) from India
Apte, D.A., R.D. Kamboj and Vishal Bhave 114

21. Synchronous spawning of the Sea Cucumber *Holothuria* (*Lessonothuria*) *pardalis* Selenka, 1867 in the Andaman Archipelago, India
Vardhan Patankar 118

BOTANY

22. *Scleria multilacunosa* T. Koyama and *S. rugosa* R. Br. (Cyperaceae): additions to the flora of Karnataka, India
A.N. Chandore, N.V. Malpure and S.R. Yadav 119

23. *Eleocharis atropurpurea* (Retz.) J. Presl & C. Presl (Cyperaceae) – a new record for Andaman & Nicobar Islands and a note on its identity
A.N. Chandore, M.Y. Kamble and K.V.C. Gosavi 120

24. Effective mode of pollination in respect of reproductive success of *Jatropha curcas* L.
Kanak Sahai and K.K. Rawat 122

Cover Photograph: Wolf *Canis lupus*
by Dhritiman Mukherjee

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Editorial

Connect and Conserve

We generally do not care for or love a thing which we do not know. Then how can we expect anyone to protect a species or a habitat about which he/she does not know anything? In order to develop a larger constituency for conservation, we have to connect people to species and their habitats. Both print and social media play an important role in creating mass awareness, in other words, connecting people to the conservation issues.

This connection or awareness was amply proved by the huge concern demonstrated by the general public towards the decline of the House Sparrow *Passer domesticus*. There are many more critically endangered species in the world but the masses get fired up when the issue of House Sparrow comes up, although this little bird is still common in rural landscapes. This concern is mainly because we *know* the House Sparrow, we connect with it, we have lived with it, and we have seen it in our houses and gardens. Its decline in built-up urban areas is noticed and becomes a cause for concern. It is very similar to the decline of American Robin *Turdus migratorius* in the USA in the 1950s and 1960s due to heavy use of pesticides (primarily DDT). When Rachel Carson pointed out in her seminal book THE SILENT SPRING that this familiar bird is dying out after eating pesticide-laden insects, the general public got alarmed. When a common garden bird with which I have grown up disappears, why will I not get concerned? Carson had given many other examples in her book, but no other bird fired up the imagination as the Robin did. This shows the power of connection of wildlife with people.

The popularity of channels such as National Geographic, Animal Planet, and BBC Wildlife shows that people like to see animal stories. There is an innate desire in human nature that connects us with animals. We may not have visited the fabulous places shown in these documentaries, but we can get vicarious pleasure in watching them. It gives us inner satisfaction that there are wonderful places in the world where nature reigns supreme.

The best way to connect people with nature is to take them to nature. Anyone who visits a sanctuary or a national park, even for a day, develops an attachment to the place. One may not become a great conservationist but neither would one oppose the protection of such an area. Even hedonistic picnickers enjoy nature. What they do there leaves much to be desired, but that is another matter.

India has nearly 640 protected areas, and some of them are extremely popular with the people. Even the Central and State governments advertise PAs to attract tourists. But we have not explored the full potential of wildlife tourism as a conservation tool. I frequently hear from PA managers that tourists are a problem. Yes, in some cases they are, but wildlife tourism is not going to go away, so it is better to manage it and use it for conservation and public awareness. Unfortunately, many of these popular parks have become too expensive for the general public to visit. Some of them have become playgrounds for rich spoilt brats who consider tiger-watching a fashion statement. They may not do much for wildlife conservation but these are the people who pay to live in expensive resorts that employ locals. Many such resorts run the local economy, helping the marginal people: thus runs the argument for high-end tourists and costly resorts. There is certainly some merit in this argument, but I would prefer a middle path. Besides such resorts for high-spender tourists, we should have middle-level hotels and resorts near PAs, which an average middle-class Indian family can afford. They can be taken inside the PA in battery-driven buses to learn about and enjoy nature. In this way, we can build up a large constituency for conservation.

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Another important step that is urgently required, and is being done in some well-managed PAs, is to take local people around the PA to see what has been protected. In many areas, people living within even a kilometre of a PA have never been inside! Nearby colleges and schools can be charged subsidized rates to visit a PA. The emphasis should be on visiting the nearest PA to appreciate the value of local flora and fauna, instead of going off to a far-off popular park to see tiger, rhino, and elephant. For instance, school children from Tinsukia and Dibrugarh in Assam are brought to Kaziranga, but many have not visited Dibru-Saikhowa National Park which is 12 km from Tinsukia town. Similarly, Uttar Pradesh has some splendid wetlands (most of them neglected) such as Lakh-Bahosi, Sandi, Saman, Samaspur, and Khurra, but people prefer to go to Keoladeo NP in Rajasthan as it is well-known with good facilities. The UP Government is very keen to increase tourist traffic, both local and international. If the government develops the wetlands carefully for regulated tourism, they could receive thousands of visitors. A person who sees a flight of 10,000 ducks or a flock of 100 Sarus Crane would never forget the scene, and would surely develop empathy for conservation.

Groups that need to be sensitized and connected with nature are lawyers, judges, and top bureaucrats of the district, region, and state. Many conservation battles are won and lost in court. Although our judges go according to the law of the land, a nature-sympathetic judge is always helpful. Similarly, district collectors have great powers. Fortunately, the new generation of Indian Administrative Officers is fully aware of conservation laws. I know a few young district collectors who have done more for conservation during their tenure than many conservationists have done in their lifetime. I also happened to go with a young collector to Dudhwa National Park, his first visit to any PA. In two days, he was a changed man – from initially criticizing the forest department for stopping *vikas* and being anti-people, he came out of the Park promising to stop all encroachment on forest land.

Conservation battles cannot be won without political support. Globe-trotting conservationists, hopping from one international meeting to another and preaching to the converted, should spend some time with local politicians who can destroy a natural area by taking a faulty decision, sometimes due to ignorance. I went to Desert National Park with a politician to show him the beauty of the critically endangered Great Indian Bustard. After seeing this grand bird, majestically walking in the grasslands of Sudasari core area, he started singing hosannas. He promised that he would do everything to protect the State Bird of Rajasthan. I was told that he spoke to the Chief Minister to start Project Bustards. This was the power of connecting with the species. One of the reasons why tiger conservation has had such success is that people relate it with the pride of India, a part of our natural wealth, a beauty to be appreciated and conserved. Unfortunately, this is not the case with many species which are dying unwept, unprotected, and unsung.

Besides the emotional connection, another very important reason for conservation is economic. A few months ago, a minister in Maharashtra strongly advocated declaring Umred Kharandla, a forest in his constituency, as a Tiger Reserve because he saw the economic benefit of a tiger reserve in Tadoba-Andhari. His argument was that once tiger-tourism is developed, local people will benefit in Umred Kharandla. Tiger-tourism is a multi-crore business. Though at present most of the economic benefit goes to resort owners and rich tour operators, with proper administrative and legal changes, we can make sure that greater benefit goes to local people.

Asad R. Rahmani

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MAPPING THE POTENTIAL DISTRIBUTION OF THE CRITICALLY ENDANGERED FOREST OWLET *HETEROGLAUX BLEWITTI* IN INDIA

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The Forest Owlet *Heteroglaux blewitti* was discovered and described scientifically in the 1870s, but went unrecorded since 1880s until 1997; it was believed to be extinct for 113 years. Although the species was rediscovered and has now been intensively studied, the limits of its geographic distribution remain poorly known. This study related known occurrences of the species to remote-sensed environmental landscape characteristics to generate ecological niche models that helped to identify potential distributional areas. We detected the species during field surveys at one location not known previously to hold populations of the species, and identified many other possible areas of distribution for the species using our niche models.

Key words: Forest Owlet, *Heteroglaux blewitti*, Ecological Niche Modeling, conservation

INTRODUCTION

Conservation of globally threatened species requires accurate information about their status and distribution (Ferrier 2002; Funk and Richardson 2002). In recent years, considerable use has been made of ecological niche models as a robust, quantitative source of such information (Guisan and Zimmermann 2000; Segurado and Araújo 2004; Peterson *et al.* 2011). This technique relates the occurrence of species to the environmental characteristics of occurrence sites to erect correlational models of appropriate conditions, which in turn are used to map potential distributional areas.

A particular challenge in ecological niche modeling has been that of choosing species for which occurrence patterns is little-known. Often, information available is not sufficient to permit fitting a comprehensive ecological niche model, sufficing only for a partial model that may be indicative of parts of the species' environmental responses. Several studies have outlined simple methodologies that show promise (Almeida *et al.* 2009; Guisan *et al.* 2006; Jarvis *et al.* 2005; Menon *et al.* 2010; Menon *et al.* 2012; Siqueira *et al.* 2009), but such studies face two interconnected challenges: (1) small sample sizes (Hernandez *et al.* 2006; Shcheglovitova and Anderson 2013; Stockwell and Peterson 2002; Wisz *et al.* 2008), and (2) the dispersal- or population-limited nature of these species' distribution which make them what has been termed "Wallacean" species, for which ecological niches are notoriously difficult to characterize (Jiménez-Valverde *et al.* 2010; Owens *et al.* 2013; Saupe *et al.* 2012). Hence, while developing correlational models for little-known species one should not presume to characterize a full fundamental ecological niche for the species; these models may provide useful distributional predictions.

The Forest Owlet *Heteroglaux blewitti* is a critically endangered species of India (BirdLife International 2014). It was first collected by F.R. Blewitt, in December 1872 in Phuljhar district (now in Chhattisgarh) in central India. It was described by A.O. Hume in 1873 (Hume 1873). During 1878–1884, six additional specimens were collected from the central plateau of peninsular India: one from Karial (now Khariar) near the Udet (now Udanti) river in Sambalpur in Odisha; four from Taloda district, and one from Shahad district of northwestern Maharashtra (Rasmussen and Collar 1998). Apart from reports based on specimens apparently stolen from existing collections and relabelled by the infamous Col. R. Meinertzhagen (Rasmussen and Collar

1999), no further records of this bird appeared in more than a century (King and Rasmussen 1998; Ripley 1976). The species was considered extinct for 113 years, until its rediscovery in 1997 in Toranmal Reserve Forest, Shahad, Nandurbar district, Maharashtra (King and Rasmussen 1998; Rasmussen and Collar 1998, 1999).

Subsequent studies on the ecology of the species have been carried out in earnest. Aspects of its biology such as vocalization (Rasmussen and Ishtiaq 1999), food and behaviour (Ishtiaq *et al.* 2002), cronism (Ishtiaq and Rahmani 2000a), and breeding biology and conservation (Ishtiaq and Rahmani 2004) have been studied. These studies were followed by a 3-year study (2001–2004) that delved into habitat requirements, foraging ecology, breeding biology, behavioural ecology, threats, and conservation issues (Jathar and Rahmani 2004, 2011). One study assessed interspecific interactions (Yosef *et al.* 2010), while another alleged hybridization between Forest Owlet and Spotted Owlet *Athene brama* (Pande *et al.* 2011), which was subsequently refuted by Jathar and Patil (2011), Ishtiaq (2011), and Rasmussen and Collar (2013).

The Forest Owlet is crepuscular and diurnal, occurring in forests classified as 'tropical dry deciduous' forest (5AC1/a-b; Champion and Seth 1968), falling in biogeographic zone 6E, the Deccan Central Highlands of the Satpuda-Maikal Hills (Rodgers and Panwar 1988). The species is apparently sensitive to disturbance, and appears to prefer teak *Tectona grandis* dominated open forest, interspersed with grasses, herbs, and (at least at some sites) shrubs (Ishtiaq and Rahmani 2004; Ishtiaq *et al.* 2002; Jathar and Rahmani 2004, 2011; Mehta *et al.* 2007).

Although many detailed studies have been carried out on the species, the full extent of its geographic distribution remains poorly known. Its known extant distribution is highly restricted, which suggests that its populations are highly endangered. The species is known to occur at present only in Maharashtra and Madhya Pradesh in central India. This knowledge gap places a premium on novel approaches to anticipate possible additional populations in other regions of India. Hence, this study aimed to use ecological niche modelling to explore the potential distribution of the species.

METHODS

Input data

We used the 174 occurrence data for the species accumulated from previous studies post-2000 (1997 to the present; Chavan and Rithe 2009; Chavan *et al.* 2013; Ishtiaq *et al.* 2002; Jathar and Rahmani 2004, 2011; Mehta *et al.* 2007) for the current study (Refer to Table 1 for summary). After removing duplicates, 51 spatially unique point locations remained for development of dependable models (Hernandez *et al.* 2006; Pearson *et al.* 2007). We also drew GPS-based (i.e., precision ≤100 m) occurrence data that corresponded to various behaviours (e.g., roosting, nesting, foraging), from Jathar and Rahmani (2004, 2011), to permit testing for differences in environmental use between different behaviours.

Given the relatively fine resolution of the occurrence data, we were eager to develop our ecological niche models at the finest spatial resolution possible. Climatic data interpolated from weather station or climate model data are known to have a broad spatial autocorrelation structure and spatial anomalies representing error in geo-referencing and/or interpolation, such that they do not offer enough detail for the purposes of this study (Peterson *et al.* 2011). Although fine-resolution elevation data are available, we avoided these data as well, as they are known to be problematic, owing to unreliable associations with causal variables (e.g., temperature; Peterson *et al.* 2011).

As a consequence, to characterize environmental landscapes, we drew fine-resolution environmental data from the MODIS satellite, summarized as the Normalized Difference Vegetation Index (NDVI; UMD, 2001). NDVI provides an index to photosynthetic mass, such that changes in this index over annual cycles are highly indicative of vegetation type, seasonality, and land use (Huete *et al.* 2002; Scharlemann *et al.* 2008). We used all 46, 16-day composite coverages for 2012–2013; this time period was chosen so that our model outputs would reflect land-use patterns that are current, particularly given that the owlets are remarkably constant at sites where they have been detected since as far back as 1997. These multi-temporal NDVI data sets have proven highly informative as inputs to ecological niche models in past applications (Bodbyl-Roels *et al.* 2011), including rare-species applications in India (Menon *et al.* 2010, 2012), such as the model developed herein.

To keep environmental spaces for development of our models as simple as possible, we identified an area of analysis corresponding to a maximum area that we deemed likely to be relevant to the species (Barve *et al.* 2011), bounded by 71.1–87.2° E and 16.4–26.4° N. For model calibration, evaluation, and comparison steps, we used still smaller subsets of this broad area of interest, as is described below. To simplify the environmental space into fewer, orthogonal dimensions, we applied a principal component analysis on the covariance matrix, and retained sets of 5, 10, and 21 principal components, which summarized 94.4%, 96.8%, and 99.0% of overall variance in the original data sets, respectively, in the form of new composite major axes of variation. This procedure is widely accepted in the niche and distribution modelling community as a means of both reducing dimensionality of environmental space and reducing colinearity among environmental dimensions (Peterson *et al.* 2011).

Model calibration

Our initial focus was on testing the ability of our models to provide useful information on the potential distribution of the species. We used Maxent (version 3.3.3k) to develop all analyses reported herein, because of the robust nature and broad adoption of this algorithm (Elith *et al.* 2006); we used default settings for parameters such as prevalence, regularization multiplier, and density of background sampling, but created multiple replicate models and explored the implications of different combinations of environmental variables. For model calibration, we used only the recent, fine-resolution occurrence data, dividing them at random into two equal-sized groups for model calibration and evaluation.

We developed models based on each of the two random subsets of the occurrence points, and tested each against the other random subset. We chose to use a threshold-independent approach in model evaluation, to avoid the need for the assumptions involved in thresholding model predictions (Fielding and Bell 1997). In light of the disparity in confidence corresponding to known occurrences *versus* non-occurrence information in niche models, which invalidates the usual approaches to model evaluation (e.g., traditional receiver operating characteristic approaches, kappa; Lobo *et al.* (2008) and Peterson *et al.* (2008)), we tested results using a partial receiver operating characteristic (ROC) approach. This approach allows differential weighting of type I and type II errors in models (Peterson *et al.* 2008); because our occurrence data were based on GPS readings by knowledgeable observers, we assumed an expected error rate of $E = 0$ (Peterson *et al.* 2007) in these tests.

The area across which models are evaluated is known to impact evaluation outcomes (Barve *et al.* 2011). We therefore restricted our model evaluations to a conservative testing area of ≤130 km from recent occurrence points (the greatest spatial separation between any pair of GPS-based occurrence points). The zero-error assumption led us to use least training presence thresholding approaches to convert continuous initial model outputs into binary maps for interpretation (Pearson *et al.* 2007).

Owl activities

GPS-based occurrence data was available for three activities (roosting, nesting, foraging) that were identified in the field during studies of habitat use by Forest Owlets (Jathar and Rahmani 2011). After filtering to retain only spatially unique points, 48 roosting points were established based on observations of night-time and diurnal roosts, 5 active nests were located and monitored during 2001–2004, and 23 foraging sites were reported.

We tested for consistent environmental correlates that might distinguish among activity types using niche identity tests (Warren *et al.* 2008, 2010). This test involves comparisons among points that are in two classes (e.g., nesting *versus* roosting). The points are mixed between the two classes at random in a number of replicate analyses, and the observed level of similarity is compared to the distribution of similarity values in the random replicates to detect whether the observed difference is unexpected (Warren *et al.* 2008, 2010). We tested niche identity across two areas, ≤17 km and ≤130 km from occurrence points, to provide two areas for testing, as these areas affect outcomes of tests of niche similarity (Barve *et al.* 2011). Niche identity tests were based on 1000 replicate resampling of occurrence data, and we used the lower 5th percentile of the null distribution of similarities as the critical value for comparison with observed niche similarity (*I* and *D* indices) values (Warren *et al.*, 2008). This test tends toward Type 1 errors, in which the null hypothesis of niche identity is rejected rather easily (Peterson *et al.* 2011).

Potential distributional area

We calibrated ecological niche models over the area <130 km of GPS-based occurrence data records. Once models were calibrated, we projected them to the broader area described above that represents a maximum area of interest for possible searches for this species.

The models were calibrated based on each of the three environmental data sets (the first 5, first 10, and first 21 principal components of the NDVI data) described above. Models based on fewer parameters generally identify broader areas as suitable, whereas models based on more parameters identify narrower areas as suitable, reflecting increasing degrees of over fitting of models (Peterson and Nakazawa 2008; Peterson *et al.* 2011).

Independent evaluation of model predictions

Finally, we designed a series of rapid surveys at key sites, as indicated by model predictions. Teams of ornithologists with considerable experience with Forest Owlets visited four sites across the study region. These sites included Gadchiroli (20.118° N, 80.361° E, 220 m, November 7–9, 2014), Pench Tiger Reserve (21.657° N, 79.260° E, 425 m, November 10, 2014), Akole (19.463° N, 73.827° E, 600 m, February 24–25, 2015), and Tansa

Wildlife Sanctuary (19.692° N, 73.191° E, 250 m, January 24–27, 2015 and March 13–14, 2015). Although our visits were perhaps not sufficiently lengthy to establish absence of the species definitively, presence records were informative as tests of the predictive ability of our models in anticipating new distributional areas of this rare species.

RESULTS

The distribution of known recent Forest Owlet occurrences across central India is shown in Fig. 1. We tested the ability of our initial models to anticipate random subsets of occurrence data for calibration and evaluation of models: both reciprocal tests among the two subsets yielded predictions significantly better than random expectations, with AUC ratios above 1.0 in all random iterations of the model evaluation. Hence, both tests indicated significant predictive ability of models ($P < 0.01$).

Comparing modeled ecological niches among different activity types revealed no striking distinctions in environmental correlates of Forest Owlet activities. Indeed, in all cases, observed niche similarity was within the 95% confidence interval of the distribution of null similarity values: in no case (roosting *versus* nesting, nesting *versus* foraging, foraging *versus* roosting) regardless of the size of the background area used, could we reject the null hypothesis of niche similarity among activities ($P > 0.05$).

Our final model predictions (Fig. 1) indicated a series of disjunct potential distributional areas across central India, which appears generally associated with the distribution of dry deciduous forests in central India. The potential distribution identified by the 5-layer model (Fig. 1) identified broad areas of the Satpuda Mountains, northern Western Ghats, Vindhya Mountains, and the east coast of India, for a total of 70,697 sq. km. All known localities fell within this relatively broad modeled distribution. The 10-layer model (Fig. 1) identified a more restricted area (5,625 sq. km): this area was confined to narrower areas of the Satpuda Mountains, northern Western Ghats, western Vindhya Mountains, and some parts of the east coast, and includes

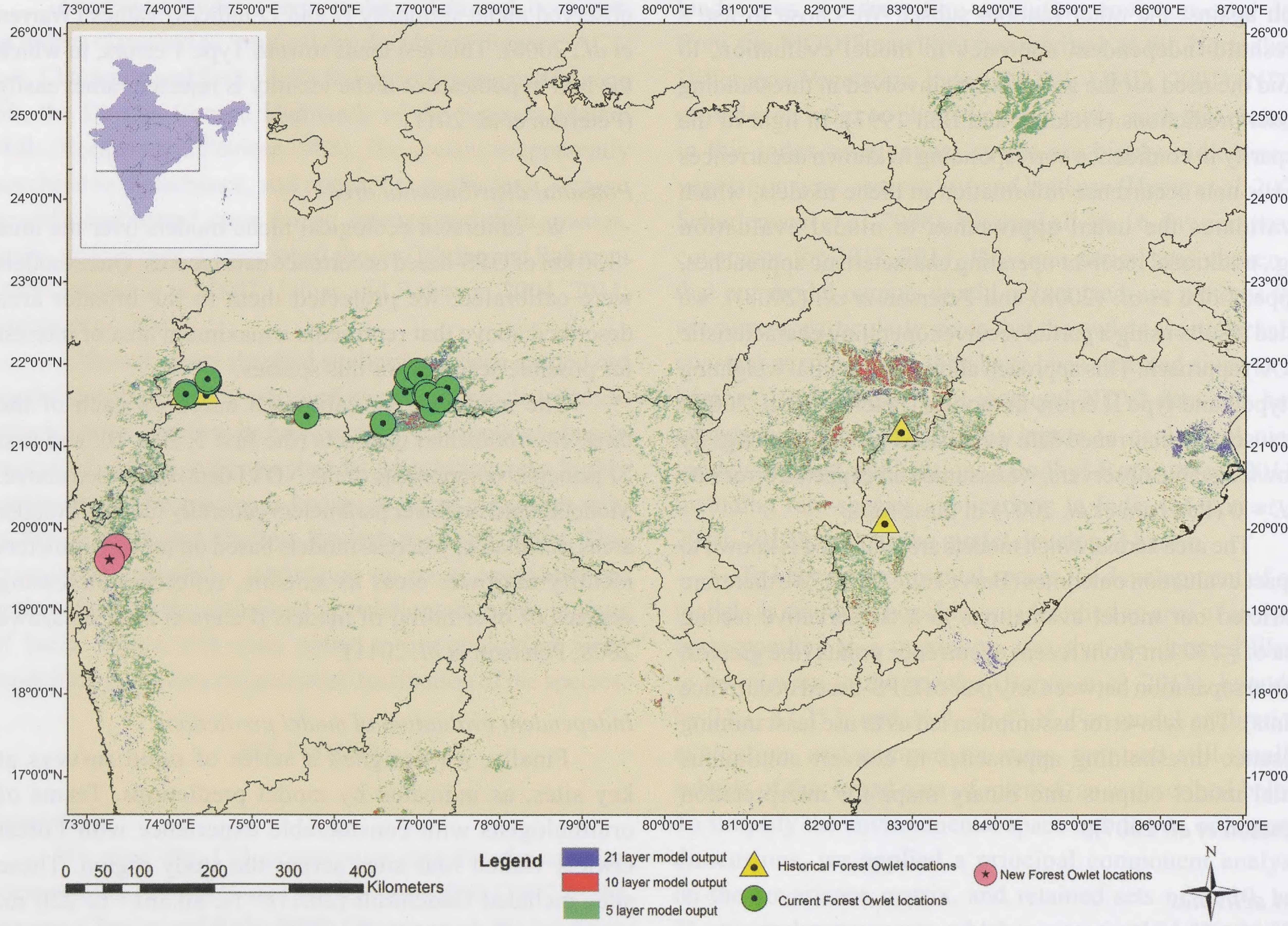

Fig 1: Modeled potential distributional areas for Forest Owlets based on 5 (green shading), 10 (red shading), and 21 (purple shading) principal components. Note that the 21-component map is a subset of the 10-component maps, which is in turn a subset of the 5-component map, such that overlaying the three maps is appropriate, and shows all information

or approaches almost all known localities for the species. Finally, the 21-layer model (Fig. 1) covered only 4,315 sq. km, and identified narrow and restricted areas in the Satpuda Mountains, northern Western Ghats, along the east coast, and some patches in the Vindhya Mountains. However, this model omitted several key localities for the species, corresponding to the eastern areas near the type locality, as well as areas farther west documented in recent surveys.

Four areas were identified as suitable that were not known to hold Forest Owlet populations, and were targeted for survey as part of this project. These areas included Gadchiroli, Pench Tiger Reserve, Akole, and Tansa Wildlife Sanctuary in Maharashtra. About 12 days were spent in search of the Forest Owlet between November 2014 and March 2015 in these localities. Although the habitat at Gadchiroli and Pench Tiger Reserve were similar to those used by known Forest Owlet populations, we could not locate any bird. In Akole, the habitat was different owing to the crest line of the Western Ghats where the forest changes to moist-deciduous and semi-evergreen, which does not correspond to the known habitat of the species. However, following on initial reports (Laad and Dagale 2014), in Tansa Wildlife Sanctuary, we confirmed 3 new sites for Forest Owlets that were located close to the areas indicated by the models as constituting potential habitat.

DISCUSSION

Setting conservation priorities for any critically endangered or restricted-distribution species requires detailed information on its geographic distribution, as such information helps to accord high priority in conservation decisions to areas holding key populations or concentrations of rare and endangered species (Guisan *et al.* 2013). For little-known species such as the Forest Owlet, the first step is that of creating lists of known occurrences and predictive maps of candidate sites at which detailed, on-ground searches can be carried out, which was the principal objective of this study.

Our 10-layer (model) results probably represented the best balance between over fitting and consequent omission of important sites (21-layer model) and overly broad predictions that include many unsuitable sites (5-layer model). Our

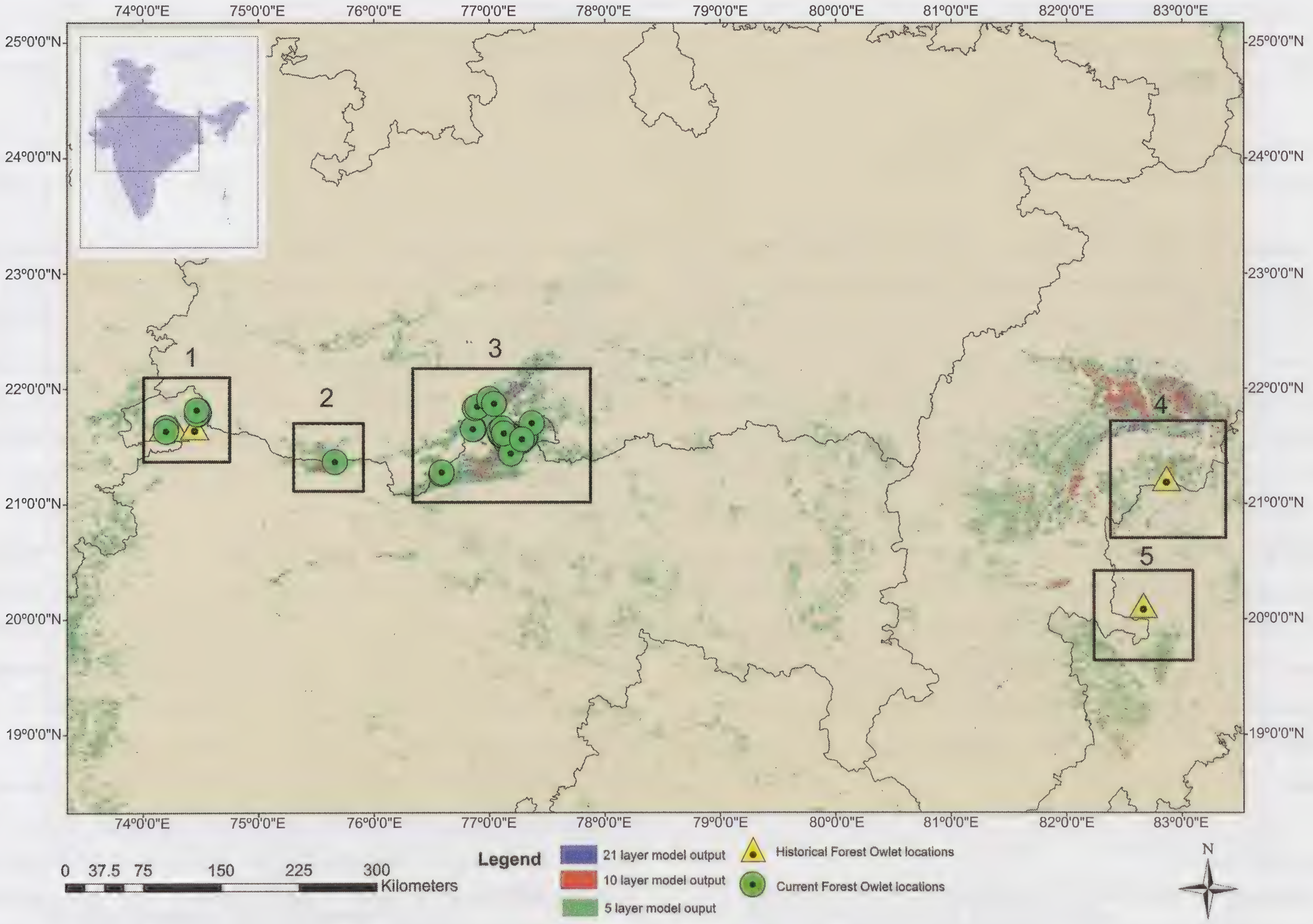

Fig. 2: Region-wide view of potential distributional areas for Forest Owlets, according to models based on 5 (green shading), 10 (red shading), and 21 (small areas of purple shading) principal components. Note that the 21-component map is a subset of the 10-component maps, which is in turn a subset of the 5-component map, such that overlaying the three maps is appropriate, and shows all information

Table 1: Previous studies of the status and distribution of Forest Owlets, constituting literature sources of occurrence data for this study

Site number	Location	Year	No. of occurrences	Activity	Source
1	Toranmal Reserve Forest, Maharashtra	1999–2004	76	Roosting, nesting and habitat use	Ishtiaq and Rahmani 2000; Jathar and Rahmani 2004
2	Taloda Reserve Forest, Maharashtra	1999–2000	2	Occurrence	Ishtiaq and Rahmani 2000
3	Melghat Tiger Reserve, Maharashtra	2004–2006	77	Roosting, nesting and habitat use	Jathar and Rahmani 2004; Mehta *et al.* 2007
4	Yawal Wildlife Sanctuary, Maharashtra	2004	1	Occurrence	Chavan and Rithe 2009
5	Narnala Wildlife Sanctuary, Maharashtra	2012	1	Occurrence	Chavan *et al.* 2013
6	Khaknar Forest Range, Madhya Pradesh	1999–2006	2	Occurrence	Ishtiaq and Rahmani 2000; Mehta *et al.* 2007
7	Piplod Forest Range, Madhya Pradesh	2005–2006	8	Occurrence	Mehta *et al.* 2007
8	East Kalibhit Forest Range, Madhya Pradesh	2005–2006	2	Occurrence	Mehta *et al.* 2007
9	Basnah, Phuljar, Chhattisgarh (Type Locality)	1872	1	Holotype, collected by F.R. Blewitt	Rasmussen and Collar 1999
10	Khariar, Sambalpur, Odisha (Second Locality)	1877	1	Valentine Ball Collection	Rasmussen and Collar 1999
11	Western Khandesh, Maharashtra	1880–84	3	James Davidson Collection	Rasmussen and Collar 1999
	Total		**174**		

model identified five clusters of potential distributional area in a narrow belt along the Satpuda Range of central India (Fig. 2). Forest Owlets had never been reported from the east coast or from the Western Ghats so that we were, in fact, initially tempted to discard areas in these regions as not falling within the dispersal 'reach' of the species. However, recent discoveries place the species in the Western Ghats (Laad and Dagale 2014; Patel *et al.* 2015), provoked us to revisit our concept on the distributional limits of the species. Focused searches for populations of this species across more sites in central India, extending south and west into the Western Ghats, are needed to verify the presence or absence of the species in and around the areas of modeled presence; this study serves as a guide for appropriate sites for these searches.

Known populations

Known Forest Owlet populations are concentrated in three areas of Maharashtra and Madhya Pradesh. The first (Fig. 2, Box 1) is in Toranmal and Taloda reserve forests: Toranmal Reserve Forest was the rediscovery site (King and Rasmussen 1998); Taloda populations were discovered by Ishtiaq and Rahmani (2000b), although surveys in Taloda since 2000 have not located any Forest Owlets (Jathar and Rahmani 2004; Jathar and Patil 2011). Toranmal populations have been declining, such that a more recent 15-day survey yielded only a single pair (Jathar and Patil 2011). Both sites are under intense anthropogenic pressure (Ishtiaq and Rahmani 2000b; Jathar and Rahmani 2004, 2011; Jathar and Patil 2011).

The second area (Fig. 2, Box 2) is Yawal Wildlife Sanctuary of Maharashtra and adjoining parts of Madhya Pradesh, in central Satpuda. A pair and young were observed there in 2004 (Chavan and Rithe 2009), but subsequent surveys failed to locate the species (Mehta *et al.* 2007). This site is under tremendous anthropogenic pressure.

The largest known population of the species is in the third area (Fig. 2, Box 3) in the central Satpuda Range. This cluster includes the Melghat Tiger Reserve of Maharashtra, and the Khaknar, Piplod, East Kalibhit, and West Kalibhit forest areas of Madhya Pradesh. Melghat holds the largest known population of Forest Owlets (Jathar and Rahmani 2004, 2011; Mehta *et al.* 2007) (Table 1). In 2012, Chavan *et al.* (2013) detected an individual Forest Owlet from Narnala

Wildlife Sanctuary, Akola district, in Maharashtra, which confirmed occurrence at 920 m, an unusual elevation record.

Forested habitats in the Melghat TR are relatively well-protected, and see minimum human disturbance. Indeed, 96% of the potential distribution identified in our models, which is within protected areas, falls within this Reserve; this indicates the importance of Melghat TR to the survival of the species. The fourth and fifth areas (Fig. 2, Box 4 and 5) correspond to the type locality and collection site of the second specimen, in eastern Chhattisgarh and western Odisha, respectively, which are discussed below.

A recent discovery placed Forest Owlets in Tansa Wildlife Sanctuary (Laad and Dagale 2014), a site within the Western Ghats. This discovery constitutes in effect a validation of our model, as it occurred after our model development phase. The discovery site fell very close (<500 m) to areas identified as falling within the modeled potential distribution of the species, based on the 10-layer model. Recent visits to this area (November 2014, March 2015, 6 field days) by Jathar and Patil yielded three additional sites, all within the predictions of the 5- and 21-layer models, and <1,500 m of sites predicted as suitable in the 10-layer model.

We assessed the alleged occurrence site near Mandvi town on the Tapti river (Ali and Ripley 1969; Rasmussen and Collar 1999; Ripley 1976) reported by Meinertzhagen, based on stolen and relabelled specimens, based on our model predictions. This site fell >12 km from potential distributional areas identified in the 10- and 21-layer models, but within the broad suitable areas identified by the 5-layer models. The fraudulent site lies ~100 km south of the Taloda Reserve Forest, where Forest Owlets have been recorded reliably, although a recent discovery places the species in Gujarat, fairly close to Mandvi (Patel *et al.* 2015).

Historical localities

Chhattisgarh (Fig. 2, Box 4): Chhattisgarh state holds extents of tropical moist deciduous forest and tropical dry deciduous forest, covering 59,772 sq. km. Of this forested area, 4.2% was included within the modeled potential distribution of Forest Owlets. The type locality of the species, 'Basnah' village, falls very close to potential distributional

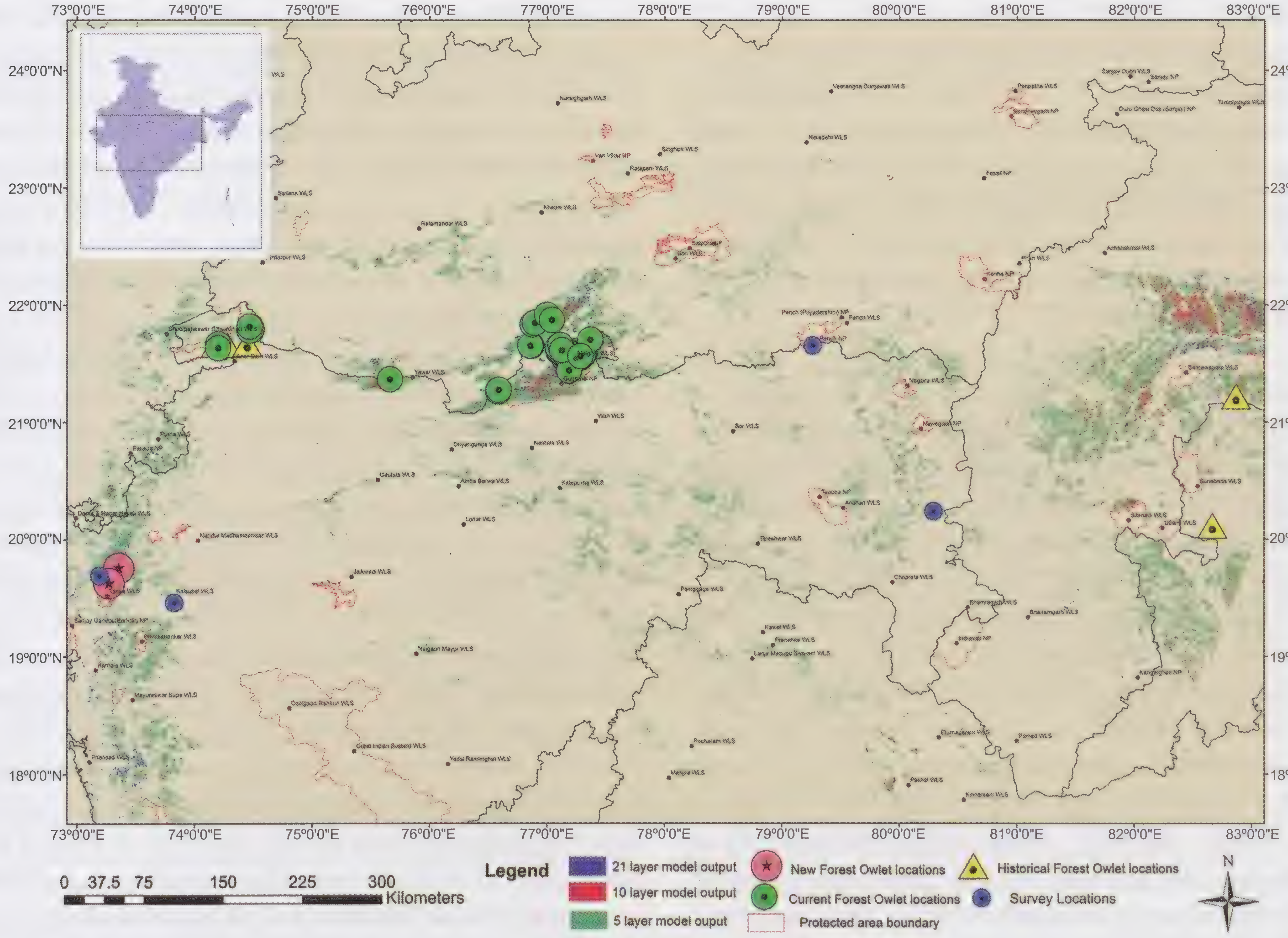

Fig. 3: Region-wise view of potential distributional areas for Forest Owlets, across protected areas of Maharashtra, Madhya Pradesh, Chhattisgarh, Odisha, Gujarat, and Rajasthan according to models based on 5 (green shading), 10 (red shading), and 21 (small areas of purple shading) principal components

areas identified by our 10-layer model that was based on the modern occurrence localities that are much farther west.

Previous field studies (Mehta *et al.* 2007) covered 9 of 16 districts in this state. Those surveys covered 102 locations along a 204 km transect (including the type locality), but did not locate any Forest Owlet populations. It appears that though classified as dry deciduous forests, these forests are moister and denser than in Madhya Pradesh and Maharashtra. Anthropogenic pressures such as grazing, fuel wood collection, and tree-cutting are rampant, and fragmentation and loss of forests may have reduced quality of the forests as Forest Owlet habitat, leading to the species' disappearance. Forest Owlets, if populations still exist in Chhattisgarh, are likely to be limited to small pockets.

Odisha (Fig. 2, Box 5): Odisha state holds areas of tropical semi-evergreen forest, tropical moist deciduous forest, tidal swamp forest, tropical dry deciduous forest, and dry bamboo brake, which cover 48,366 sq. km. Of this area, only 1.6% fell within the modeled potential distribution of Forest Owlets. The second location from where the species was collected, Khariar village, falls <2 km of the modeled potential distribution of the species.

Mehta *et al.* (2007) surveyed 4 of 30 districts in this state during 2005–2007, in areas of dry deciduous forest at 60 locations along a 120 km transect, but failed to find Forest Owlet populations. The forests in the state are under considerable anthropogenic pressure, such that the species may have disappeared or may persist only in small pockets. Indeed, teak forests in the state are scattered as small blocks among other forest types, and may represent suboptimal habitat for Forest Owlets.

Presence and absence

Our models identified several sites (Fig. 3), protected areas in particular, that could profitably be visited and checked for Forest Owlet populations: Tungareshwar Wildlife Sanctuary, Kalsubai Harishchandragad Wildlife Sanctuary, Nagzira Wildlife Sanctuary, Tipeshwar Wildlife Sanctuary, and Andhari Wildlife Sanctuary in Maharashtra; Bori Wildlife Sanctuary, Raitapani Wildlife Sanctuary, and Pench National Park in Madhya Pradesh; Bansda National Park and Shulpaneshwar Wildlife Sanctuary in Gujarat; Dadra and Nagar Haveli Wildlife Sanctuary in Dadra and Nagar Haveli; Sitanadi Wildlife Sanctuary, Barnavpara Wildlife Sanctuary, Udanti Wildlife Sanctuary, and Kaneghati National Park in Chhattisgarh; and Karlapat Wildlife Sanctuary, Sunabeda Wildlife Sanctuary, Debrigarh Wildlife Sanctuary, and Hadgarh Wildlife Sanctuary in Odisha.

Locations such as Bhimashankar, INS Shivaji Lonavla, and Radhanagari Wildlife Sanctuary (Maharashtra state) fell within our model predictions, but can probably be excluded from consideration, as they hold semi-evergreen forests that are dense and likely not suitable for Forest Owlets. Gangapur dam and grasslands (Maharashtra state) comprise a wetland surrounded by savanna grassland, and so also does not qualify as suitable habitat for the species. Similarly, Bhitarkanika and Chilika lake (Odisha state) are estuary and wetland habitats that resemble suitable habitats superficially, but do not appear to include habitats appropriate for Forest Owlets.

Our model results affirm the endemic and restricted-range nature of this species in the highly restricted nature of the areas identified: our maps of distributional potential showed a highly patchy and fragmented potential distribution across its range. The largest range fragment identified covered only 2,387 sq. km, constituting ~49% of the total distribution of the species based on the 10-layer model. These latter results underline the endangerment of the species under IUCN's (version 3.1) criterion B, which focuses on fragmentation of populations (IUCN 2001).

Our model predictions further indicated that >92.5% (4,511 sq. km) of the species' distribution appears to fall outside the current protected areas network. Known sites for this species (Toranmal and Taloda reserve forests, Maharashtra; Khanknar, Piplod, and West Kalibhit reserve forests, Madhya Pradesh) are known to hold populations of Forest Owlets, but still lack adequate protection. Jathar and Patil (2011) found evidence of declines in forest cover in Toranmal and Taloda reserve forests, and some Forest Owlet pairs have apparently disappeared from existing territories. As such, broad exploration of all potential areas and protection of the most viable populations will be crucial to the species' survival.

Mapping the potential distribution of Forest Owlets represents an important step in the conservation of the species, and thus has been the focus of this contribution. We developed and tested a series of ecological niche models that capture environment-occurrence correlations that appear to constrain the distribution of this species, and thereby identified a series of sites that the models indicate as suitable for the species. We hasten to add that this 'suitability' is at the spatial resolution that was possible and in terms of the multi-temporal NDVI characterization of the environment that we were able to assemble. Clearly, our conclusion of suitability must be backed up by on-ground surveys to detect and document all remaining populations of the species. We have visited and checked several sites, but we present this contribution to facilitate inspections and searches by others as soon as possible (our three sets of model predictions are available in .kml format to facilitate visualization in Google Earth, at http://hdl.handle.net/1808/20763), in light of this critical conservation challenge.

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DISTRIBUTION, ABUNDANCE, AND HABITAT SIGNATURE OF THE INDIAN GIANT FLYING SQUIRREL *PETAURISTA PHILIPPENSIS* (ELLIOT 1839) IN THE WESTERN GHATS, INDIA

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The distribution and abundance of the Indian Giant Flying Squirrel (IGFS) *Petaurista philippensis*, with respect to environmental variables, were investigated along the Western Ghats of Karnataka, Kerala, and Tamil Nadu. In Karnataka, a stretch of 1,582 km of forest trails and roads was sampled with spotlight searches between November 2001 and July 2004, while 127 and 133 points were sampled by the audio lure method in Kerala and Tamil Nadu respectively, between June 2005 and December 2008. Altogether, 418 individuals were recorded from 35 of the 38 forest stations sampled. The mean abundance of the IGFS was 0.187/km (± 0.234) in Karnataka, and 0.638/point (± 0.281) and 0.308/point (± 0.343) in Kerala and Tamil Nadu respectively. The southern distribution limit of the species in India was recorded as Kanyakumari Wildlife Sanctuary. Overall, the mean abundance of IGFS was higher in the rainfed, mid-altitude slopes of deciduous and evergreen forests in Tamil Nadu and Kerala. Tree density, tree height, GBH (girth at breast height), canopy height and canopy cover were the key factors influencing the distribution of the species on the micro scale, while on the macro scale (home range) were the large extents of wet evergreen and moist deciduous forests. The study indicated that conservation of large trees with large trunk girth and thick canopy cover is necessary for the survival of the species in the Western Ghats.

Key words: India, Western Ghats, Indian Giant Flying Squirrel, *Petaurista philippensis*, habitat characteristics

INTRODUCTION

Tropical forests have two unique characteristics: high species richness and a more distorted biome than any other forest on earth (Bawa and Dayanandan 1997; Myers *et al.* 2000). The destruction of forests and its impact on specialist fauna and flora of tropical forest have been assessed to some extent in the Indian region (Jha *et al.* 2000; Prasad 1998; Ramesh *et al.* 1997). Arboreal mammals are often considered for such an evaluation (Umapathy and Kumar 2000) because of their strong association with canopy contiguity and density (Datta and Goyal 2008). Among the arboreal mammals, squirrels are recognised as indicator species of ecological health (Borges 1993; Kumara and Singh 2006; Ramachandran 1988).

Flying squirrels are largely nocturnal and shelter in tree holes during the day. They are an important component of the ecosystem as they are a major prey base for several avian top predators (Kavanagh and Bamkin 1995). A total of 44 species of flying squirrels are known to occur in the world with a varied range of distribution, of which 12 are known to occur in India (Srinivasulu *et al.* 2004). Only two species, the Indian Giant Flying Squirrel *Petaurista philippensis* and Small Travancore Flying Squirrel *Petinomys fuscocapillus* are distributed in the Western Ghats (Prater 1980; Rajamani *et al.* 2001; Srinivasulu *et al.* 2004), and the rest occur in the north and north-eastern parts of India (Srinivasulu *et al.* 2004).

The Indian Giant Flying Squirrel (IGFS) has a wide range of distribution including South Asia, southern and central China, mainland Southeast Asia (Walston *et al.* 2008), and a population occurs in the Western Ghats (Kumara and Singh 2006; Rajamani *et al.* 2001; Umapathy and Kumar 2000). IGFS has been categorised as Least Concern by IUCN, however, the population in the Western Ghats and India has a decreasing trend due to high hunting pressure and fragmentation of potential habitat (Kumara 2007; Kumara and Singh 2004; Walston *et al.* 2008).

A recent review on tree squirrels and flying squirrels highlighted that tropical countries especially of the south and southeast Asian countries are hotspots of squirrel diversity, but scientific publications on squirrels remain low (Koprowski and Rajamani 2008). Till the last decade, information on the distribution and habitat characteristics of IGFS in India was restricted to anecdotal notes (Ashraf *et al.* 1993; Hutton 1949); however, in recent years, a few intensive studies have been undertaken (Koli *et al.* 2011; Kumar *et al.* 2002; Umapathy and Kumar 2000). One of these was a survey of flying squirrels in southern Western Ghats to assess the population status of IGFS and Small Travancore Flying Squirrel (Rajamani *et al.* 2001). Others were on the impact of habitat fragmentation (Umapathy and Kumar 2000) and hunting practices on flying squirrels (Kumara 2007) of the Western Ghats. However, the habitat characteristics that influence the distribution of IGFS have not been studied in the Western Ghats. In this paper, we report the distribution and abundance of IGFS in the Western Ghats areas of Karnataka, Kerala, and Tamil Nadu, and the habitat characteristics that influence their distribution and abundance in Kerala and Tamil Nadu. The studies were carried out from November 2001 to July 2004 in Karnataka, and from June 2005 to December 2008 in Kerala and Tamil Nadu.

STUDY AREA

The Western Ghats, located between 8° to 21° N, spread over five states, namely Kerala, Tamil Nadu, Karnataka, Goa, and Maharashtra (Pascal 1988), from the river Tapti in the north to the southern tip of peninsular India, namely the Mahendragiri hills of Kanyakumari Forest Division. This almost unbroken relief dominates the west coast of peninsular India for almost 1,400 km (Nair 1991), covering an area of 160,000 sq. km. It is interrupted only by the 40 km wide Palghat Gap. The Western Ghats consist of two major categories of rocks, the pre-Cambrian shield, and the basaltic lava flows of the Deccan Trap north of Goa (Pascal 1988). Nair (1991) divided the Ghats into three subregions, i. the Maharashtra Sahyadris (from Tapti river to south of Goa), ii. Current (Central) Western Ghats (from south of Goa to Coorg), and iii. Southern Western Ghats (South Coorg to Mahendragiri).

The vegetation assemblage in the Ghats is impacted by both the monsoons (southwest monsoon and northeast monsoon), duration of dry months, and the atmospheric temperature. The rainfall pattern is distinctive in two directions, viz., north to south and east to west (Nair 1991). The temperature ranges from 13 °C to 33 °C. At low altitudes, the mean temperature is more than 23 °C; in median altitudes, it ranges between 16 and 23 °C. The mean of the minima of the coldest month is more than 15 °C along the crest.

MATERIAL AND METHODS

Sampling of IGFS

The Western Ghats areas that run through Karnataka, Kerala, and Tamil Nadu were covered in this study with 19 wildlife sanctuaries (WS), 4 national parks (NP), 8 tiger reserves (TR), and 7 reserve forests (RF) (Fig. 1).

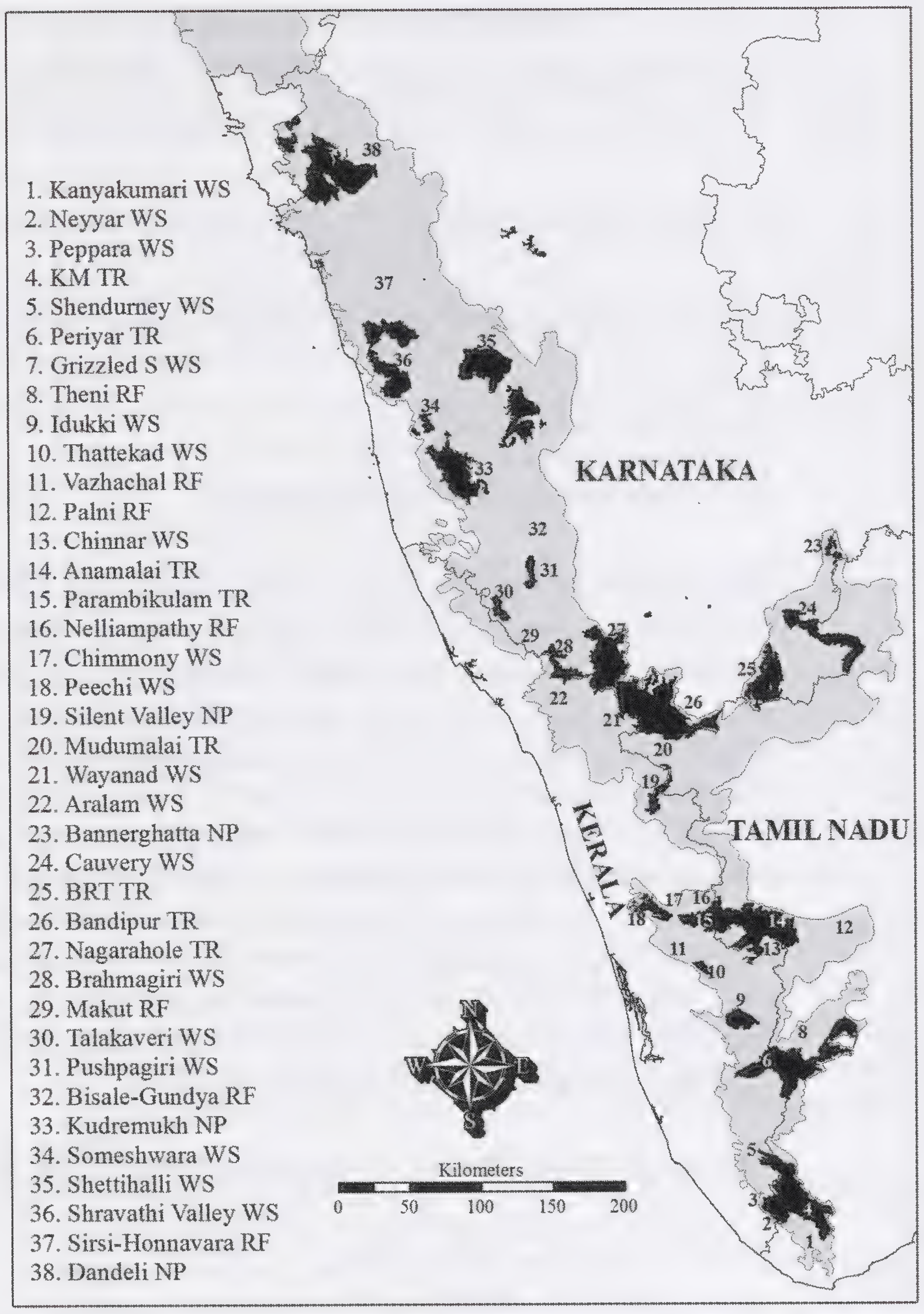

Fig. 1: Surveyed sites in the Western Ghats for IGFS between 2001 and 2008

In Karnataka, a 1,582 km stretch along trails and forest roads was surveyed, using spotlights on a jeep travelling at 5 km/hour. The speed of the vehicle was maintained uniform across the sampling transects to ensure equal sampling effort. Night walks with torches were also carried out at a few places, where there were no roads/trails (Kumara and Singh 2006).

Observation point (modified from watch tower observation) with audio lure (Ashraf *et al.* 1993) was followed at 260 locations; 133 in Tamil Nadu and 127 in Kerala. A distance of at least 2 km was kept between the sampling points (Kuo and Lee 2012). The response of IGFS was elicited by playing back the predator calls of owls, which are reported to increase the detection rate of IGFS (Babu and Jayson 2009). Spotlight searches were also done for 15 minutes in the immediate vicinity of the sampling site to detect IGFS that were not responding to the calls.

Vegetation Sampling

The habitat characteristics of each sampling point in

Kerala and Tamil Nadu were studied by the Point-Centred Quarter (PCQ) method (Mueller-Dombois and Ellenberg 1974) to assess the differences in habitat between IGFS occurrence and non-occurrence sites. Four transects of 100 m length (one in each direction from the centre of each squirrel sampling point) were established. With 5 sampling points per transect at 20 m distances from each other, the vegetation of 20 sampling points were analysed. At each point, the distances between the nearest four trees and the sampling point were measured, and the distances were averaged to calculate the tree density.

The vegetation characteristics assessed at the micro scale were tree density (ha), tree height (m), trunk girth i.e. GBH (girth at breast height cm), tree canopy height (m), tree canopy cover (%), climbers (%), and snags (counts). At the macro scale, the extent of vegetation types in a two kilometre radius from the IGFS sampling points was assessed through vegetation and other topographic data obtained from the GIS laboratory of the Kerala Forest Research Institute. The vegetation types were categorised into six major types, namely evergreen, semi-evergreen, moist deciduous, dry deciduous, scrub forest and plantations (Teak *Tectona grandis*, Tea *Camellia sinensis*, Coffee *Coffea arabica*, and Cardamom *Elettaria cardamomum*). Altitude was classified into two gradients: low (<750 m) and mid (>750 m). Slope values were categorised into four classes: 0 to 5.5, >5.5 to 10.4, >10.4 to 18.2, and >18.2.

The abundance of IGFS was calculated as the number of individuals sighted per sampling point in Kerala and Tamil Nadu, and the number of individuals sighted per km walked in Karnataka. The Chi-square test was used to test the significance of the differences in habitat variables (vegetation types, altitude, and slope) for Kerala and Tamil Nadu. Mann-Whitney U test was used to test the differences in micro and macro-scale characteristics in occurrence and non-occurrence sites of IGFS. For all the tests, the threshold significance level was set as less than 0.10. All the statistical analysis was carried out using SPSS 9 statistical package.

Table 1: Distribution and abundance of IGFS in the Kerala and Tamil Nadu areas of the Western Ghats

Protected Area/Reserve Forest	Status	No. of individuals	Individuals / point	Vegetation covered
Kerala				
Aralam WS	PA	3	0.429	MDF, WE
Chimmony WS	PA	4	0.667	MDF, WE
Chinnar WS	PA	0	0.000	DDF, R
Idukki WS	PA	2	0.182	MDF, WE
Nelliampathy RF	RF	8	0.889	WE, PL
Neyyar WS	PA	3	1.000	MDF
Peppara WS	PA	3	0.750	MDF, PL
Parambikulam TR	PA	3	0.500	MDF, PL
Peechi-Vazhani WS	PA	25	0.781	SE, MDF, WE
Periyar TR	PA	9	0.692	SE, MDF, WE
Shendurney WS	PA	3	0.750	MDF, MIS
Silent Valley NP	PA	6	0.857	WE
Thattekad Bird Sanctuary	PA	3	0.600	MDF, PL, R
Vazhachal RF	RF	3	0.333	WE, MIS
Wayanad WS	PA	6	0.857	SE, DDF
Tamil Nadu				
Anamalai TR	PA	9	0.818	DDF, PL, MDF, WE
Kanyakumari WS	PA	2	0.167	WE, PL
Mudumalai TR	PA	6	0.667	DDF, DTF
Palni Hills	RF	6	1.000	WE, DDF, R, DTF
Grizzled Squirrel WS	PA	3	0.375	DTF, R
Theni RF	RF	4	0.200	WE, DTF
Kalakkad-Mundanthurai TR	PA	11	0.164	SE, MDF, WE, PL, DDF, R, DTF

WS=Wildlife Sanctuary; NP=National Park; TR=Tiger Reserve; RF=Reserved Forests; PA=Protected Area; WE=Wet Evergreen; SE=Semi-Evergreen; MDF=Moist Deciduous; R=Riparian; DDF=Dry Deciduous Forest; PL=Plantations; MIS=Miscellaneous; DTF=Dry Thorn Forest

RESULTS

Distribution and Abundance

The abundance of IGFS in the Western Ghats ranged from 0.00 squirrels/point to 1.00 squirrels/point. The abundance of IGFS was 0.187 squirrels/km in the sampled sites in Karnataka, 0.638 squirrels/point in Kerala and 0.308 squirrels/point in Tamil Nadu (Tables 1 and 2). A lower abundance (0.15 squirrels/point) was observed in the eastern slopes (rain-shadow zones) compared to the western slopes (0.37 squirrels/point) in Kerala and Tamil Nadu. The southernmost distribution limit of the species in India was recorded in Kanyakumari WS (8.45197° N; 77.40183° E).

Karnataka: IGFS was detected in all the surveyed areas except Bannerghatta NP and Cauvery WS. The mean abundance for the state was 0.187 squirrels/km. Its abundance was highest in Nagarahole TR (1.0 squirrels/km) and lowest in Dandeli NP (0.067 squirrels/km).

Kerala: IGFS was recorded from all the surveyed areas, except Chinnar WS and Attappady RF. Out of 137 sampling points, a total of 85 individuals (0.62 squirrels/point) were recorded from 51 points. Its abundance was highest in Neyyar WS (1.0 squirrels/point) and lowest in Idukki WS (0.182 squirrels/point).

Tamil Nadu: IGFS was recorded in 21 of 139 sampling points. Its abundance was highest in Palni Hills (1.0 squirrels/point) and lowest in Kalakkad-Mundanthurai TR (0.17 squirrels/point).

Factors affecting the distribution

Altitude and Topography: The abundance of IGFS varied significantly across the altitudinal gradients (χ^2=8.393; *df*=1; *p*=<0.005) with the highest abundance recorded in mid altitudes (750–1,500 m) (Table 3). The abundance varied significantly across the slope gradients (χ^2=9.803; *df*=3; *p*=<0.05), the highest abundance was recorded in areas with moderate slope (Table 3).

Vegetation types: The abundance showed clumped distribution in relation to the vegetation types (χ^2=71.689; *df*=4; *p*=<0.001), and IGFS was mostly recorded from moist deciduous forest followed by wet evergreen forest (Table 3). The species was not recorded from scrub forest.

Tree structural characteristics: Of the seven habitat variables of tree structure quantified to assess the key parameters that regulate the distribution of IGFS, tree height (Z=-2.413; *df*=2; <0.01), GBH (Z=-2.593; *df*=2; <0.01), canopy height (Z=-1.961; *df*=2; <0.05) and canopy cover (Z=-2.406; *df*=2; <0.05) were found to be significantly higher in sites with IGFS occurrence. The number of snags (Z=-2.335; *df*=2; <0.05) was also significantly higher in occurrence than non-occurrence sites, while climbers were comparatively less in occurrence sites (Table 4).

Table 2: Distribution and abundance of IGFS in the Karnataka areas of the Western Ghats

Protected Area/Reserve Forest	Official Status	km covered	No. of individuals	Individuals / point	Vegetation covered
Bannerghatta NP	PA	213	0	0.000	DDF, R
Cauvery WS	PA	19	0	0.000	DDF, R
Biligiri Rangaswamy Temple TR	PA	462	51	0.110	SF, DDF, MDF, WE
Bandipur TR	PA	120	11	0.092	SF, DDF, MDF
Nagarahole TR	PA	121	121	1.000	SF, DDF, MDF
Brahmagiri WS	PA	32	9	0.281	MDF, WE
Makut RF	RF	22	6	0.273	MDF, WE
Talakaveri WS	PA	80	18	0.225	MDF, WE
Pushpagiri WS	PA	32	8	0.250	MDF, WE
Bisale-Gundya RF	RF	123	4	0.033	MDF, WE
Kudremukh NP	PA	40	5	0.125	MDF, WE
Someshwara WS	PA	22	3	0.136	MDF, WE
Sharavathi Valley WS	PA	69	16	0.232	MDF, WE, PL
Shettihalli WS	PA	48	6	0.125	SF, DDF, MDF, PL
Sirsi-Honnavara RF	RF	119	34	0.286	MDF, WE
Dandeli NP	PA	60	4	0.067	DDF, MDF, PL, R

WS=Wildlife Sanctuary; NP=National Park; TR=Tiger Reserve; RF=Reserved Forests; PA=Protected Area; WE=Wet Evergreen; MDF=Moist Deciduous; R=Riparian; DDF=Dry Deciduous Forest; PL=Plantations; SF=Scrub Forest

Table 3: Distribution pattern of IGFS in the southern Western Ghats

Parameter	Category	Abundance	
		Kerala and Tamil Nadu	Karnataka
Altitude (m)	Low (0 – 750)	0.48	-
	Medium (751 – 1,500)	0.62	-
Slope (°)	0 – 5.5	0.34	-
	>5.5 – 10.40	0.64	-
	>10.40 – 18.20	0.59	-
	>18.20	0.48	-
Vegetation types	Scrub	0.00	0.043
	Dry deciduous forest	0.26	0.369
	Moist deciduous forest	0.81	0.411
	Plantation	0.41	0.077
	Semi-evergreen	0.56	-
	Wet evergreen	0.46	0.197

Vegetation configuration: The occurrence of IGFS was significantly higher in the sampling sites with large tracts of moist deciduous (Z=-3.632; *df*=2; <0.01) and wet evergreen forests (Z=-2.694; *df*=2; <0.01) (at 2 km radius) (Table 4). Its occurrence was lower in semi-evergreen forests (Z=-1.911; *df*=2; <0.10), scrub forest (Z=-4.727; *df*=2; <0.01) and non-forested areas (Z=-2.058; *df*=2; <0.05).

DISCUSSION

Prater (1980) stated the distribution of IGFS to be the larger forests of the Peninsula south of the Ganges. Rajamani *et al.* (2001) reported the distribution and status of IGFS for some locations of southern Western Ghats of Tamil Nadu and Kerala. Based on available literature, Menon (2009) published a distribution map of the species in India. However, all these publications do not clearly depict the distribution of the species in the southern Western Ghats. Through our study, we were able to map the distribution of the species in Tamil Nadu, Kerala, and Karnataka. Kanyakumari WS in Tamil Nadu was recorded to be its southernmost limit in the Western Ghats and in India.

There were no sight records in Bannerghatta NP and Cauvery WS, despite intensive search efforts. Biligiri Rangaswamy Temple TR was found to be the easternmost distribution limit in the Western Ghats. The abundance was highest in Neyyar WS (Kerala), where the dominant vegetation type is moist deciduous forests, which is reported to be the preferred vegetation type of the species (Kumara and Singh 2006). In Tamil Nadu, the abundance was highest in Palni

Table 4: Patch characteristics of IGFS occurrence and non-occurrence plots at micro and macro scale

Parameters	Non-occurrence	Occurrence	Z	Asymp. Sig. (2-tailed)
	Mean (*SD*)	Mean (*SD*)		
Micro scale				
Tree density (trees/ha)	418.30 (±263.92)	499.09 (±294.52)	-1.767	<0.10
Tree height (m)	10.88 (±4.89)	12.90 (±3.00)	-2.413	<0.01
Tree GBH (cm)	68.55 (±33.56)	80.76 (±28.56)	-2.593	<0.01
Tree canopy height (m)	5.93 (±3.08)	6.86 (±2.56)	-1.961	<0.05
Tree canopy cover (%)	43.69 (±22.42)	52.80 (±16.47)	-2.406	<0.05
No. of snags (nos.)	1.61 (±2.10)	2.37 (±2.36)	-2.335	<0.05
Climbers (%)	16.56 (±15.98)	14.10 (±14.61)	-0.853	ns
Macro scale				
Wet evergreen (ha)	222.29 (±355.01)	341.89 (±414.72)	-2.694	<0.01
Semi-evergreen (ha)	61.11 (±192.06)	48.40 (±188.18)	-1.911	<0.10
Moist deciduous forest (ha)	186.41 (±313.80)	334.01 (±366.60)	-3.632	<0.01
Scrub forest (ha)	215.11 (±350.41)	48.78 (±201.69)	-4.727	<0.01
Dry deciduous forest (ha)	158.31 (±322.25)	171.14 (±380.04)	-1.209	ns
Plantations (ha)	100.02 (±229.94)	103.00 (±208.61)	-0.368	ns
Waterbody (ha)	87.03 (±142.75)	107.76 (±158.01)	-0.722	ns
Non-forested area (ha)	226.57 (±356.45)	101.03 (±193.96)	-2.058	<0.05

ns= Not significant

Table 5: Mean abundance of IGFS in the vegetation types of the Western Ghats areas in Karnataka, Kerala, and Tamil Nadu

Vegetation types	Sources				
	Karnataka (Kumara & Singh 2006) *	Anamalai (Ashraf *et al.* 1993) *	Kerala &Tamil Nadu (Rajamani *et al.* 2001) *	This study (Tamil Nadu and Kerala)	This study (Karnataka) *
Shola	-	-	≥1.1	-	-
Evergreen	0.17- 0.36	0.13	1.16	0.46	0.197
Semi-evergreen	-	-	-	0.56	-
Moist deciduous	0.18	0.27	1.60	0.81	0.411
Dry deciduous	-	-	-	0.26	0.369
Plantations	0.02	0.00 – 0.50	1.36	0.41	0.077
Dry Scrub	-	-	0.00	0.00	0.043

* - mean individuals / km

Hills. Although the vegetation of Palni Hills has drastically changed due to anthropogenic pressures (Amarnath *et al.* 2003), the riparian forests and valleys (evergreen patches) in the hills still harbour IGFS. A reason for this is that the disturbance in dense habitats like evergreen and riparian forests of Palni Hills has created spacing between trees for the flying squirrels to glide freely through the forests with fewer obstacles. In Karnataka, the abundance was highest in Nagarahole TR, and this may be due to the availability of large tracts of intact moist deciduous forests. The low abundance in Bandipur TR can be attributed to invasive *Lantana camara*, which has grown high up to the tree canopy, leading to loss of landing sites for IGFSs during glides between trees.

With respect to vegetation types, the abundance of IGFS has been shown to be the highest in moist deciduous forests, through a number of studies (Table 5). On a broad scale, IGFS could be categorised as a 'generalist', because it was recorded from six out of the seven vegetation types sampled, two altitudinal gradients and all slope gradients of the southern Western Ghats. However, on comparison of the habitat characteristics around occurrence and non-occurrence sites, a distinct pattern of habitat use was observed. IGFS was not recorded from the scrub forests of southern Western Ghats (pers. obs.). An earlier study (Rajamani *et al.* 2001) reported the non-occurrence of the species in scrub forests, which can be attributed to the structural characteristics of scrub forests being largely composed of shrub species with scattered trees, resulting in poor canopy contiguity and canopy density that are vital for the survival of the species (Datta and Goyal 2008; Rajamani *et al.* 2001). IGFS uses moderate slope sites to make gliding easier without spending much energy, as gliding is energy expensive (Andō and Shiraishi 1993).

Overall, the abundance of IGFS was higher in the wet zone (rain-fed areas) than in the dry zone (rain-shadow areas) of the southern Western Ghats. However, north of the Nilgiris, the abundance of IGFS was equally high in the dry and moist tracts. This can be attributed to the altitude and precipitation pattern; the altitude of the Western Ghats south of Nilgiris abruptly rises from sea level to crest and falls to the plains within a few kilometres, resulting in varied pattern of precipitation along the longitude. The western side of the crest receives more rainfall, resulting in the formation of wet and moist forests, whereas the eastern tract receives low rainfall and has dry forests. In contrast, north of the Nilgiris, the altitude rises to the crest and forms plateaus of mid altitude, which receive high rainfall. While moving eastwards, the intensity of rainfall decreases, which leads to formation of moist and dry forests (Pascal 1988).

Kumara and Singh (2006) reported that the distribution of IGFS was confined to forests with tall trees in Karnataka. Our study indicated that tree density, trunk girth (GBH), canopy height and canopy cover, and number of snags influence the distribution of the species. Trees of larger GBH and height will support larger tree-holes or cavities, which serve as roost and nest sites (Kavanagh and Bamkin 1995). Holloway and Malcolm (2007) stated that the distribution of flying squirrels was associated with higher densities of decayed and old trees for this reason. We did not try to record tree-holes, as our ground-based surveys with limited infrastructure generally tended to miss them.

Apart from the many structural characteristics of the habitat that influence the occurrence and abundance of IGFS, anthropogenic factors like hunting by local people also determine the variation in abundance in different sites (Kumara 2007; Kumara and Singh 2004; Madhusudan and Karanth 2002). Hence, retaining the older tress with larger girth and control on hunting are the major management requirements to conserve IGFS.

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DIATOMS IN SUB-SURFACE SEDIMENT CORES FROM MANGROVE FOREST FLOORS OF DELTAIC ISLANDS IN SUNDARBANS, INDIA

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Species constituting diatom assemblages in sediments provide important information regarding the past and present environmental conditions related to soil and water physico-chemistry and also biodiversity dynamics data. This information can reveal the developmental history of the region. Diatoms are sensitive to stochastic changes in the environment, making them extremely reliable bio-indicators. The purpose of the present study was to decipher such biodiversity related information provided by the diatom assemblages from the Indian Sundarbans. Diatoms were identified in the top 50 cm layer of two sediment cores: a newly silted up deltaic landmass with mangroves in early succession stage, and an island within the Protected Area Network with mangroves in late succession stage.

Fifteen diatom species, with no past records in the sediments of Indian Sundarbans were identified and described. Four species among them are sporadically mentioned in previous phytoplankton records from the Sundarbans, but these are not confirmed taxonomically. This paper provides identification and nomenclatural notes on all 15 species. High abundance and species richness of the centric forms *Coscinodiscus* spp., *Cyclotella* spp., and *Thalassiosira* spp. at both the sites is attributed to their proximity to estuarine rivers and their regular inundation, leading to settling of planktonic forms within sediment cores. Many pennate forms, namely *Amphicampa eruca*, *Amphora holsatica*, *Diploneis* spp. (except *D. smithii*), *Epithemia turgida*, *Eunotia pectinalis*, *Giffenia cocconeiformis*, and *Rhaphoneis rhombus* which are being reported for the first time from this region have never been part of described planktonic communities in estuarine waters, validating their 'soil diatom' status. Typical freshwater diatoms, namely *Aulacoseira granulata* and *Epithemia turgida*, in the sediments indicate lower salinity in these areas, not much earlier than present times.

Key words: Diatoms, sediment-core, deltaic mangroves, estuaries, Sundarbans

INTRODUCTION

The Sundarbans in the Ganga-Brahmaputra delta represent the world's largest single mangrove tract. The importance of the system is manifold, being home to the only mangrove dwelling tiger species and several endemic and threatened mangrove species unique to the Old World. This system has an annual gross productivity of 151.01 $gCm^{-2}y^{-1}$ (Chaudhuri *et al.* 2012) that surpasses the Gross Primary Production (GPP) of many similar estuarine systems like Ems Dollard (middle) estuary (Colijn and Ludden 1983), San Francisco Bay (Peterson 1979), Fraser River estuary (Parson *et al.* 1970), and Columbia River estuary (Anderson 1972). The contributors to the annual gross productivity include a wide range of algae in the aquatic as well as terrestrial systems. Diatoms constitute a group that significantly occupy both aquatic and terrestrial systems. A worldwide concern for the adverse impacts of climate change on several unique and threatened ecosystems like coral reefs and mangroves, based on new and strong evidences under the Risk Category-1 (IPCC 2007), add to the importance of these systems. Mangroves and estuaries are ecosystems known to be extremely sensitive to environmental fluctuations, remaining under perpetual stress and thus particularly vulnerable to climate change. Changes in the structure and function of these systems are expected to be sensitive parameters of global climate change, and would contribute to our understanding of the implications that such changes may have in the area under study.

Systematic analysis of diatom assemblages in areas undergoing rapid environmental changes can be used to evaluate the natural dynamics of the system. There have been sporadic attempts to describe and document modern diatom assemblages in the Indian Sundarbans aquatic system (Banerjee and Santra 1999, 2001, 2007; Banerjee *et al.* 2001; Biswas *et al.* 2010; Choudhury and Pal 2008; De *et al.* 2011; Manna *et al.* 2010; Santra *et al.* 1989, 1991; Sen and Naskar 2002, 2003; Sen *et al.* 2002), but there is a lacuna in terms of information regarding the sub-surface diatom genera, even though soil diatoms have proven to be extremely useful tools in reconstructing palaeo-ecological changes in many other ecosystems across the globe. The present paper documents the diatom assemblage in the first 50 cm of two sediment cores from the forest floor of the deltaic mangrove forests of Indian Sundarbans. This is the first report of such assemblage in the present study area, in particular, and the entire Indian Sundarbans in general.

List of Abbreviations:

STR	–	Sundarban Tiger Reserve
PAN	–	Protected Area Network
PoC	–	Place of Collection
DoC	–	Date of Collection
NoC	–	Name of Collector
LM	–	Light Microscope
CLS	–	Camera Lucida Sketch
SEM	–	Scanning Electron Microscope

MATERIAL AND METHODS

Sampling sites (Fig. 1)

Sampling site 1: This site is named Jharkhali, situated within 24 Parganas South Division in the PAN (22° 1′ 08.7″ N; 88° 41′ 3.1″ E). Located at the southernmost tip of Basanti Island about 40 km straight up north of the Bay of Bengal, it bears the brunt of most of the storms and cyclones that arise in the Bay. The area was subjected to anthropogenic pressures from the fringe area populace before it was brought under the PAN. The soil is predominantly silt and clay particles, with low sand content.

Sampling site 2: This site is on the bank of the island Amlamethi, opposite STR (22° 2′ 40.5″ N; 88° 43′ 52.4″ E) within PAN of Indian Sundarbans with no human settlement recorded. It is a recently formed deltaic island that has emerged in response to meander dynamics of the river and is noticeably in its developmental stage. The soil is predominantly sand and silt particles, with low clay content.

The collections were made in the field, using a manual borer of 1.8 m (about 6 ft.) capacity. The solid core was removed from the borer, dissected into 10 cm pieces, and placed in labelled sample packets. The sediment samples were subjected to hydrogen peroxide treatment, followed by hydrochloric acid treatment. The treated sample was then used for microscopic analysis, for which 50μl of the cleaned sample was placed on glass coverslips using a micro-pipette and left for complete settlement and drying. The coverslips were then inverted and mounted on permanent microscope slides using Naphrax™ (R.I. = 1.74). Permanent slides were prepared for each depth at each site for microscopic analysis. These slides are preserved in the Phycology Laboratory, University of Kalyani, West Bengal, India, under the series *PoC/DoC/Depth/Slide No./PLKU/NoC*. A minimum of 400 diatom frustules were studied for each depth.

The sample slides were studied using a Ch20i light microscope at 100x using oil immersion. Camera lucida sketches were made for each different diatom form encountered. Morphometric data were noted and various diatom identification manuals were used for identification (Cleve 1881, 1894; Cox 1996; Cupp 1943; Heurck 1896; Krammer 2002; Krammer and Lange-Bertalot 1986, 1988; Lange-Bertalot 1996; Witkowski *et al.* 2000). The website www.algaebase.org (Guiry and Guiry 2015) was consulted for nomenclature issues.

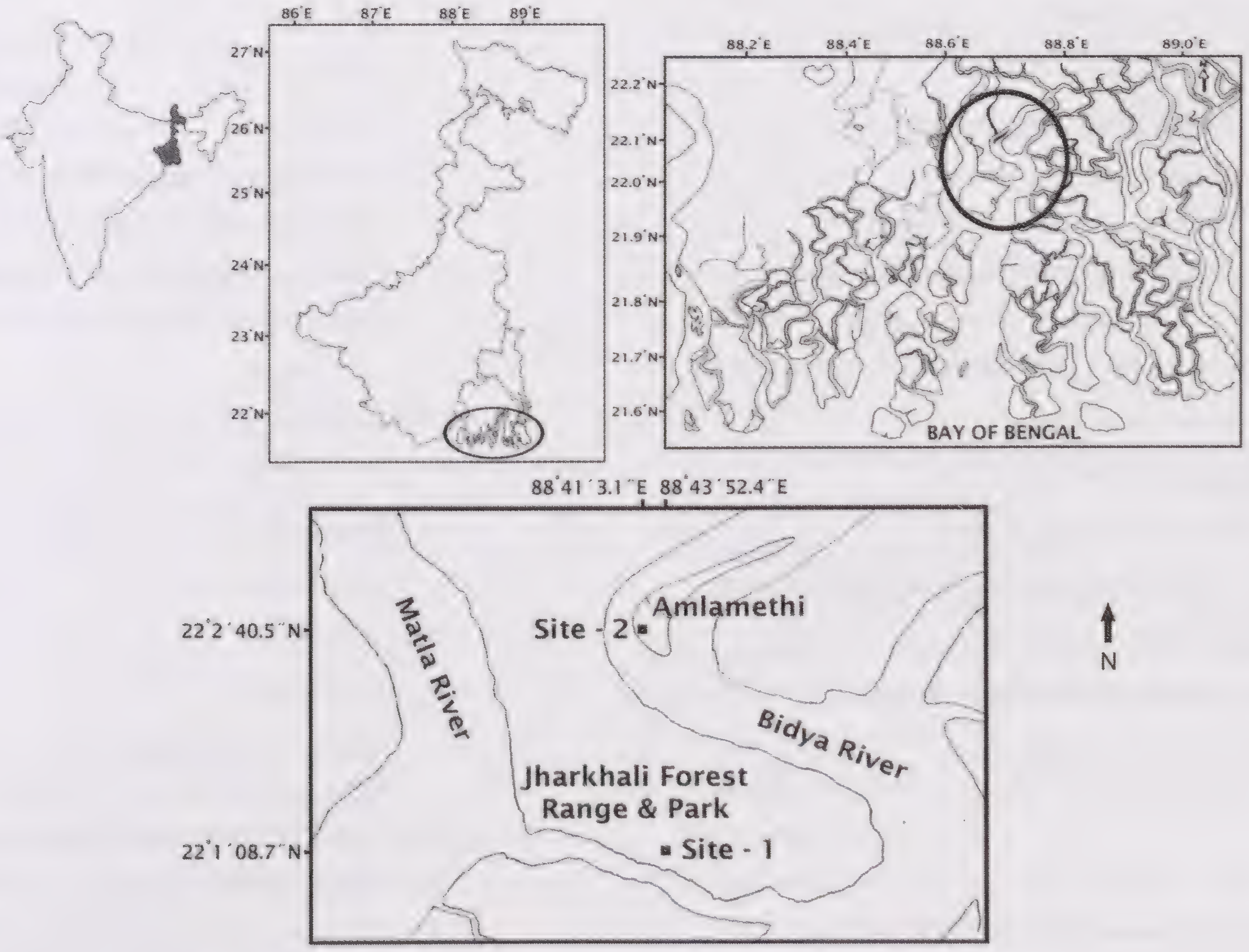

Fig. 1: Sampling sites for sediment cores in the Indian Sundarbans

For SEM imaging, cleaned samples were air-dried on 1 cm x 1 cm glass stubs. The stubs were then placed on adhesive carbon tapes and were coated with a thin layer of gold using a high resolution sputter coater. The SEM investigations were carried out using model FD Quanta 200 microscope. Both the light microscope images and the SEM images were used for species identification.

RESULTS

Microscopic analysis of the sediment samples revealed 15 species of diatoms, of which 4 species though previously reported from the estuarine waters of Indian Sundarbans have not been taxonomically confirmed (Table 1), but none of these 15 species have been recorded from sediment samples of Indian Sundarbans and taxonomically confirmed at the species level previously.

Morphology & Taxonomy:

1. Class: Bacillariophyceae
   Order: Eunotiales
   Family: Eunotiaceae
   Genus: *Amphicampa* Ehrenberg (Ralfs)
   Species: *Amphicampa eruca* Ehrenberg
   Cited in: Kociolek (2000)
   Preserved slide: Amla/3-13/0-10/003/PLKU/BB
   Fig. 2 a, b
   Valve 51.0 µm long, 10.2 µm broad (approximate, as specimen with broken tips was observed), slightly curved – dorsal margin convex and ventral margin concave with smooth wavy undulations on both the valve margins. Striae tranverse and distinctly punctate.

2. Class: Bacillariophyceae
   Order: Thalassiophysales
   Family: Catenulaceae
   Genus: *Amphora* Ehrenberg ex Kutzing
   Species: *Amphora holsatica* Hustedt
   Cited in: Krammer and Lange-Bertalot (1986); Sar *et al.* (2003)
   Slide: Amla/3-13/0-10/002/PLKU/BB
   Fig. 2 c, d
   Valves wide to semi-lanceolate, 48–50 µm long, 13–15 µm broad, with ends terminating in protruding truncate poles. Dorsal margin convex, ventral margin mainly straight with a distinct central inflation. Striae distinctly punctate and uniseriate. Row(s) of parallel areolae near raphe.

Table 1: Diatom species identified from the two sampling sites with previous records of the same from Indian Sundarbans

Sl. No.	Species name	Site 1	Site 2	Report history
1	*Amphicampa eruca* Ehrenberg	-	✓	First report
2	*Amphora holsatica* Hustedt	-	✓	First report
3	*Aulacoseira granulata* (Ehr.) Simon.	-	✓	First report
4	*Cyclotella litoralis* Lange & Syvertsen	✓	✓	First report
5	*Cyclotella striata* (Kutzing) Grunow	✓	✓	Common in phytoplankton samples; first report in soil. (Mitra 2013; Mukherjee *et al.* 2014)
6	*Diploneis smithii* (Brebisson) Cleve	-	✓	Recorded only once in phytoplankton sample; first report in soil (Mitra 2013)
7	*Diploneis bombus* (Ehr.) Ehrenberg	✓	✓	First report
8	*Diploneis ovalis* (Hilse) Cleve	-	✓	First report
9	*Epithemia turgida* (Ehrenberg) Kutz.	✓	✓	First report
10	*Eunotia pectinalis* (Kutzing) Raben.	✓	✓	First report
11	*Giffenia cocconeiformis* (Grunow) Round & Basson	✓	✓	First report
12	*Rhaphoneis rhombus* Ehrenberg	✓	✓	First report
13	*Thalassiosira tenera* Proschkino-Lavrenko	✓	✓	First report
14	*Coscinodiscus radiatus* Ehrenberg	✓	✓	Common as phytoplankton; first report in soil. (Biswas *et al.* 2014; Choudhury and Bhadury 2014; De *et al.* 1991; Mitra 2013; Mukherjee *et al.* 2014; Sarkar 2015)
15	*Coscinodiscus wailesii* Gran & Angst	-	✓	Recorded only once in phytoplankton sample; first report in soil (Mukherjee *et al.* 2014)

3. Class: Bacillariophyceae
   Order: Naviculales
   Family: Diploneidaceae
   Genus: *Diploneis* Ehrenberg ex Cleve
   Species: *Diploneis smithii* (Brebisson) Cleve
   Cited in: Cleve (1881); de Souza-Mosimann *et al.* (2011); Hendey (1964)
   Slide: Amla/3-13/40-50/056/PLKU/BB
   Fig. 2 j, k
   Valves elliptic with broadly rounded apices, 30–48 µm long, 15–30 µm broad. Central nodule small, very slightly elevated. Narrow furrows, costae distinctly punctate, especially nearer the margins, 8–10 in 10 µm.

4. Class: Bacillariophyceae
   Order: Naviculales
   Family: Diploneidaceae
   Genus: *Diploneis* Ehrenberg ex Cleve
   Species: *Diploneis bombus* (Ehrenberg) Ehrenberg
   Cited in: Cleve (1881); Park *et al.* (2012)
   Slide: Jhar/3-13/0-10/014/PLKU/MM
   Fig. 2 l, m
   Valves with elliptical to obtuse ends, deeply constricted at the centre, 40.5–55 µm long, 13.2–22 µm broad, 5.1–6.3 µm broad at constriction. Large central nodule smoothly rectangular. Narrow furrows near the margin, costae 5–8 in 10 µm, a single entire row of costae on either side of median line.

5. Class: Bacillariophyceae
   Order: Naviculales
   Family: Diploneidaceae
   Genus: *Diploneis* Ehrenberg ex Cleve
   Species: *Diploneis ovalis* (Hilse) Cleve
   Cited in: Cleve (1881); Taylor *et al.* (2014)
   Slide: Amla/3-13/40-50/057/PLKU/BB
   Fig. 2 n, o
   Valve elliptic to broadly elliptic, 35–56 µm long, 10.2–15 µm broad. Costae punctate, 9–11 in 10 µm. Longitudinal canal narrow, broadest in the middle. Large orbicular central region.

6. Class: Bacillariophyceae
   Order: Rhopalodiales
   Family: Rhopalodiaceae
   Genus: *Epithemia*
   Species: *Epithemia turgida* (Ehrenberg) Kutzing
   Cited in: Jahn and Kusber (2006); Rabenhorst (1864); Wood (1961)
   Slide: Amla/3-13/10-20/026/PLKU/BB
   Fig. 3 a, b
   Cells solitary, lanceolate, strongly dorsiventral with concave ventral margin and an arched dorsal margin. Valve faces sieve-like due to striae, prominent costae with 2–3 striae between adjacent partitions. Raphe system eccentric, frustules 65–71.4 µm long, 13–17 µm broad.

7. Class: Bacillariophyceae
   Order: Eunotiales
   Family: Eunotiaceae
   Genus: *Eunotia* Ehrenberg
   Species: *Eunotia pectinalis* (Kutzing) Rabenhorst
   Cited in: Hirano (1969); Rabenhorst (1864); Tuji and Williams (2005)
   Slide: Amla/3-13/10-20/024/PLKU/BB
   Fig. 3 c, d
   Valves elongate and elliptic, dorsiventral, symmetrical along transapical axis. Dorsal margin convex, undulate. Valve apices bluntly rounded. Striae perpendicular to central margin, extend across entire valve face. Valves 58–72 µm long, 8–8.5 µm broad. Raphe not visible in valve view.

8. Class: Bacillariophyceae
   Order: Bacillariales
   Family: Bacillariaceae
   Genus: *Giffenia* Round & Basson
   Species: *Giffenia cocconeiformis* (Grunow) Round & Basson
   Cited in: Park (2012); Rashid (2014); Round and Basson (1997)
   Slide: Jhar/3-13/0-10/001/PLKU/MM
   Fig. 3 e, f
   Valves symmetrical along both apical and transapical axes. Raphe eccentric, within a keel. Valves lack sternum. Frustule length varies between 22–30 µm, and width between 8–14.4 µm.

9. Class: Coscinodiscophyceae
   Order: Aulacoseirales
   Family: Aulacoseiraceae
   Genus: *Aulacoseira* Thwaites
   Species: *Aulacoseira granulata* (Ehrenberg) Simonsen
   Cited in: Gomez *et al.* (1995); Manoylov *et al.* (2009); Simonsen (1979)
   Slide: Amla/3-13/0-10/001/PLKU/BB
   Fig. 2 e, f, g
   Valve size ranges between 9–12 µm diameter and 10–12 µm height. Distinctly curved rows of areolae present. Areolae roundish, separating spines short pointed type.

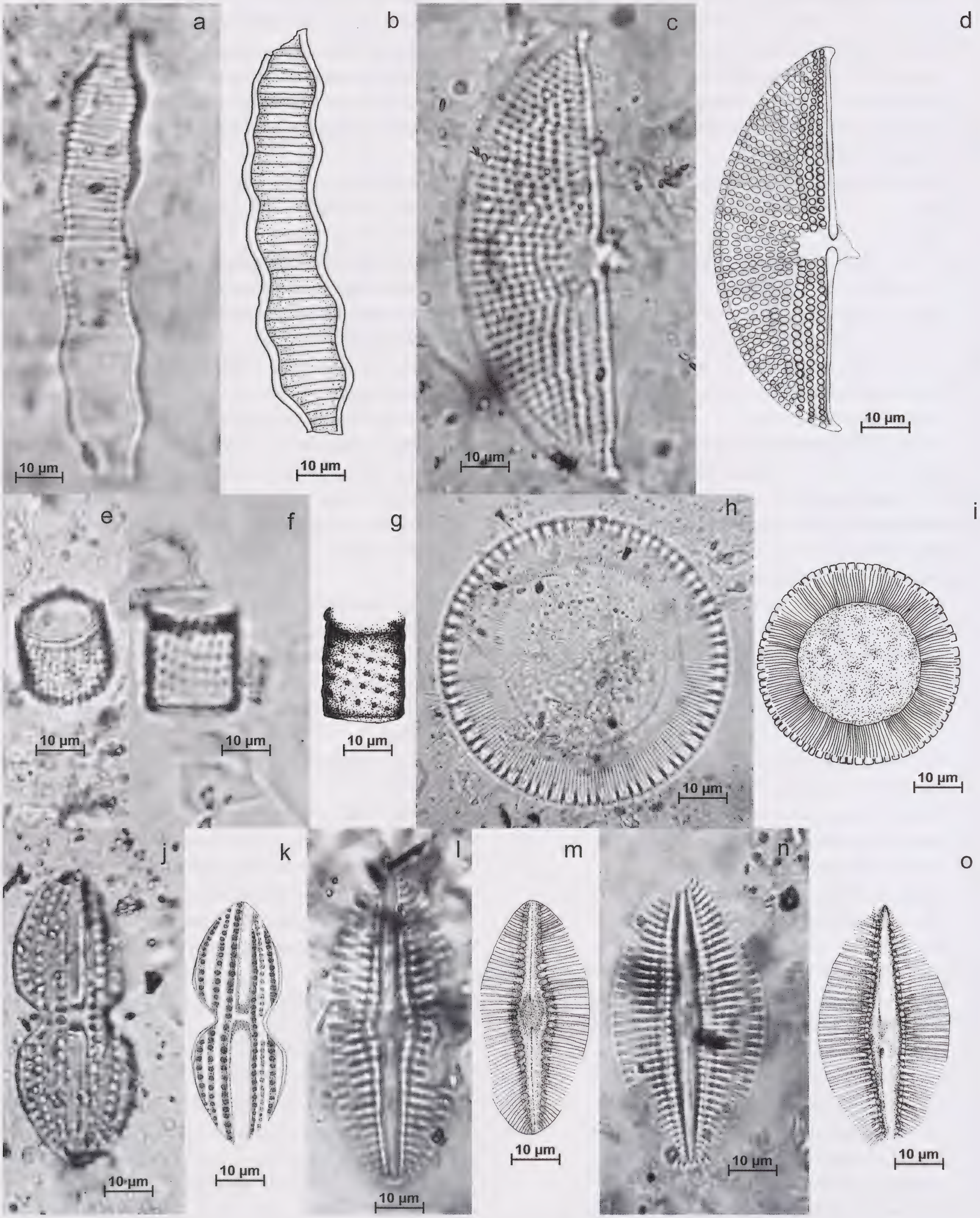

Fig. 2: a. LM image & b. CLS *Amphicampa eruca* Ehr.; c. LM image & d. CLS *Amphora holsatica* Hustedt; e., f. LM image & g. CLS *Aulacoseira granulata* (Ehr.) Simonsen; h. LM image & i. CLS *Cyclotella striata* (Kutz.) Grun.; j. LM image & k. CLS *Diploneis bombus* (Ehr.) Ehr.; l. LM image & m. CLS *Diploneis ovalis* (Hilse) Cleve; n. LM image & o. CLS *Diploneis smithii* (Breb.) Cleve

10. Class: Coscinodiscophyceae
Order: Thalassiosirales
Family: Stephanodiscaceae
Genus: *Cyclotella* (Kutzing) Brebisson
Species: *Cyclotella litoralis* Lange & Syvertsen
Cited in: Cremer *et al.* (2007); Park *et al.* (2012); Sar *et al.* (2010)
Slide: Jhar/3-13/0-10/014/PLKU/MM
Fig. 3 o, p; Fig. 4 h
Solitary cells, circular in outline, 18–48 µm in diameter, divided into two nearly equal zones: central and marginal. Central zone with variable elevation. Marginal zone with radial striae and an extreme ring of fultoportulae.

11. Class: Coscinodiscophyceae
Order: Coscinodiscales
Family: Coscinodiscaceae
Genus: *Coscinodiscus* Ehrenberg
Species: *Coscinodiscus radiatus* Ehrenberg
Cited in: Hasle and Syvertsen (1996); Sar *et al.* (2010)
Slide: Amla/3-13/20-30/045/PLKU/BB
Fig. 3 k, l; Fig. 4 a
Valves 38–56 µm in diameter. Areolae radially arranged, 6–8 areolae in 10 µm, processes not visible.

12. Class: Coscinodiscophyceae
Order: Coscinodiscales
Family: Coscinodiscaceae
Genus: *Coscinodiscus* Ehrenberg
Species: *Coscinodiscus wailesii* Gran & Angst
Cited in: Fernandes *et al.* (2001); Hasle and Syvertsen (1996)
Slide: Jhar/3-13/0-10/014/PLKU/MM
Fig. 3 m, n; Fig. 4 b, c
Valves 100–106.6 µm in diameter. Areolae arranged from centre towards periphery in straight lines. Areolae in central region smaller than those in peripheral region.

13. Class: Coscinodiscophyceae
Order: Thalassiosirales
Family: Stephanodiscaceae
Genus: *Cyclotella* (Kutzing) Brebisson
Species: *Cyclotella striata* (Kutz.) Grun.
Cited in: Hakansson (2011)
Slide: Jhar/7-14/30-40/006/PLKU/MM
Fig. 2 h, i; Fig. 4 f, g
Valves 21–68 µm in diameter. Valves with transversely undulated central area that occupies about half of the valve diameter. Central region granular. Striae 22–30 in 10 µm.

14. Class: Coscinodiscophyceae
Order: Thalassiosirales
Family: Thalassiosiraceae
Genus: *Thalassiosira* Cleve
Species: *Thalassiosira tenera* Proschkina-Lavrenko
Cited in: Hasle and Syvertsen (1997); Lee and Park (2008)
Slide: Amla/3-13/20-30/042/PLKU/BB
Fig. 3 i, j; Fig. 4 d
Valves 18–24 µm in diameter. Areolae in straight rows, 11–13 areolae in 10 µm. Marginal ring of strutted processes (fultoportulae).

15. Class: Fragilariophyceae
Order: Rhaphoneidales
Family: Rhaphoneidaceae
Genus: *Rhaphoneis* Ehrenberg
Species: *Rhaphoneis rhombus* Ehrenberg
Cited in: Hendey 1974; Jahn and Kusber 2004
Slide: Amla/3-13/40-50/PLKU/MM
Fig. 3 g, h
Rhomboid valves with slightly angular apices, 21–23 µm long, 10–11 µm broad. Valve surface flat, pseudoraphe runs straight down the central zone of the valves. Striae punctate, very slightly curved from centre to margin, punctae numbering 6 in the broadest region and 1–2 at the apices.

DISCUSSION

The 15 diatom species collected and described for the first time from sediments of Indian Sundarbans give an interesting view of the diatom assemblages therein, primarily because only four of the above-mentioned species, namely *Coscinodiscus radiatus*, *C. wailesii*, *Cyclotella striata*, and *Diploneis smithii* find mention in published literature on phytoplankton communities of the estuarine system of the region (Biswas *et al.* 2010, 2014; Choudhury and Bhadury 2014; De *et al.* 1999; Manna *et al.* 2010; Mitra 2013; Mukherjee *et al.* 2013a,b, 2014). The sporadic mention of these diatoms in various published literature does not include taxonomic and morphological data.

Morphological considerations might lead to some uncertainty in establishing the identity of these species. This uncertainty arises in the case of *Coscinodiscus radiatus*, which is very similar to *C. argus* – a common diatom in the phytoplankton of Indian Sundarbans though not reported in the present study – when observed under light microscope. The difference between the two is established only on observing areolae character of *C. argus* and *C. radiatus* under SEM. *C. radiatus* is characterized by the presence of areolae

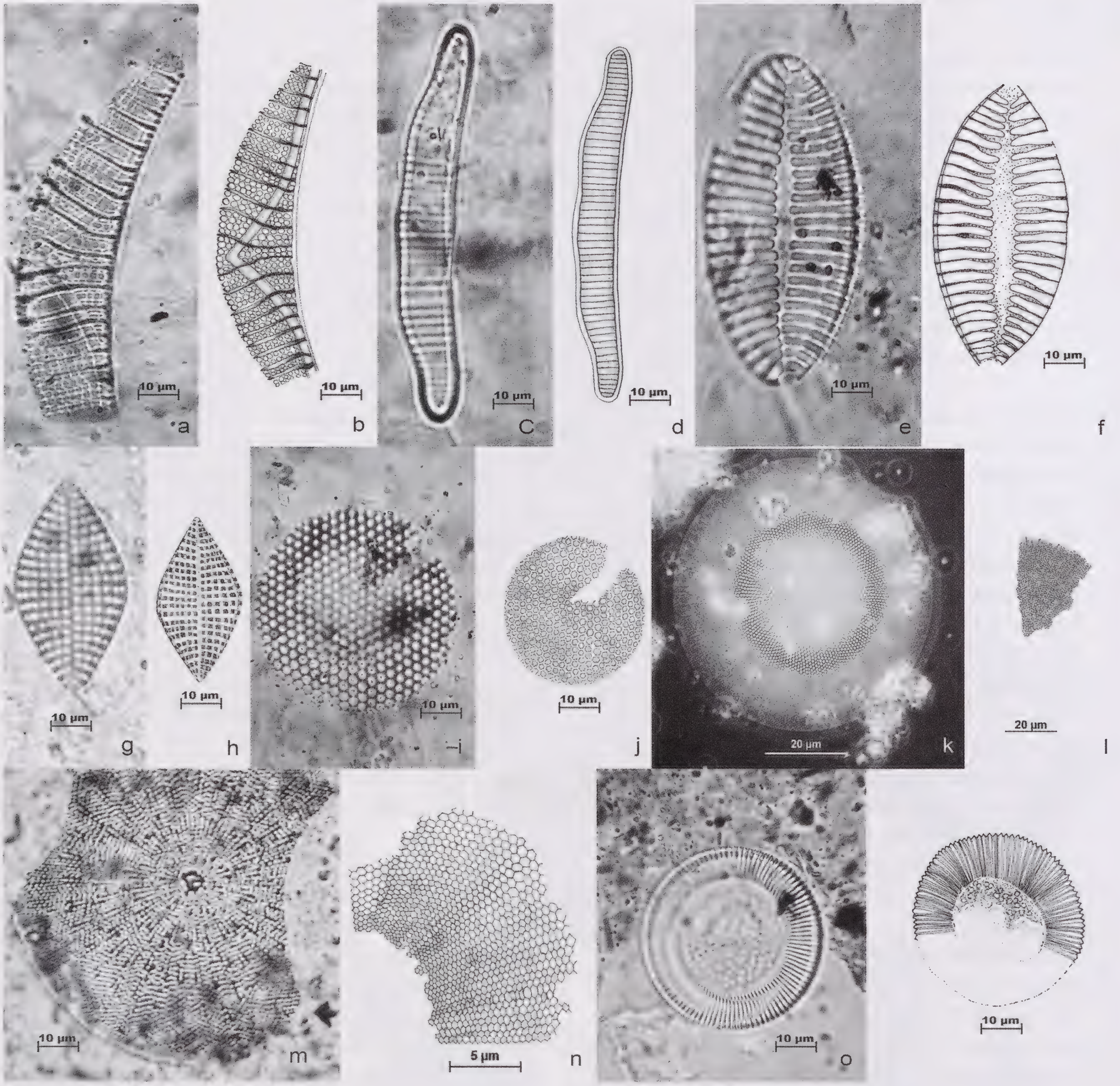

Fig. 3: a. LM image & b. CLS *Epithemia turgida* (Ehr.) Kutz.; c. LM image & d. CLS *Eunotia pectinalis* (Kutz.) Raben.; e. LM image & f. CLS *Giffenia cocconeiformis* (Grunow) Round & Basson; g. LM image & h. CLS *Rhaphoneis rhombus* Ehr.; i. LM image & j. CLS *Thalassiosira tenera* Proschkina-Lavrenko; k. LM image & l. CLS *Coscinodiscus radiatus* Ehr.; m. LM image & n. CLS *Coscinodiscus wailesii* Gran. & Angst; o. LM image & p. CLS *Cyclotella litoralis* Lange & Syvertsen

of uniform size throughout the entire valve face, while *C. argus* exhibits a gradual increase of areolae size from the centre of the valve towards the middle of the radius and then a reduction in size towards the extreme margin.

Coscinodiscus wailesii is mentioned in a few publications on phytoplankton assemblages of Indian Sundarbans (Mukherjee *et al.* 2013a, b, 2014). Morphologically under valve view, the species is similar to *Coscinodiscus concinnus* and *C. concinniformis* when observed under LM. The presence of the typical floral cribra as observed under SEM is characteristic of the species *C. wailesii* (Ferrario and Sar 1994; Hernandez-Becerril 2000; Otzen 2012) along with a high steep mantle near the periphery (Fig. 3b, c & d).

Among the two species of *Cyclotella* reported in the present study, one species *Cyclotella striata* is of common occurrence in the estuarine waters, and is additionally being reported as a soil assemblage diatom for the first time. The other species *C. litoralis* is being reported for the first time in Indian Sundarbans. The two species differ in terms of the degree of undulation of the central region, presence/absence of marginal chambers, and location of the fultoportulae. The identification of *Diploneis smithii* also poses problems as distinct morphotypes similar to those of *D. smithii* are reported to occur (Droop 1994). The species can be taxonomically confirmed only with measurements of dimensions and striation density using SEM analysis.

Other than these four species (*Coscinodiscus radiatus*, *C. wailesii*, *Cyclotella striata*, and *Diploneis smithii*), the other 11 species are being reported and described for the first time from this region, though *Diploneis* and *Eunotia* have been reported as part of the phytoplankton composition by Biswas *et al.* (2010) and Manna *et al.* (2010) respectively, but with no mention of the species identification.

A detailed comparative analysis of species composition with earlier reports could not be done since this is the first attempt to determine the species composition of diatoms in the sediments of Indian Sundarbans. However, some interesting findings are given below.

Three of the newly reported species of this region, *Aulacoseira granulata*, *Amphicampa eruca*, and *Epithemia turgida* are established freshwater species (Islam *et al.* 2010; Rashid *et al.* 2013; Skvortzow 1928; Villac *et al.* 2008; Wang *et al.* 2009; Yawen and Zhengyu 2007) whose presence in the sediments of this saline environment indicates loss of freshwater condition and increasing salinity of this area.

Giffenia cocconeiformis, being described for the first time from Indian Sundarbans, is a rare form initially described by Round and Basson (1997) based on *Nitzschia*

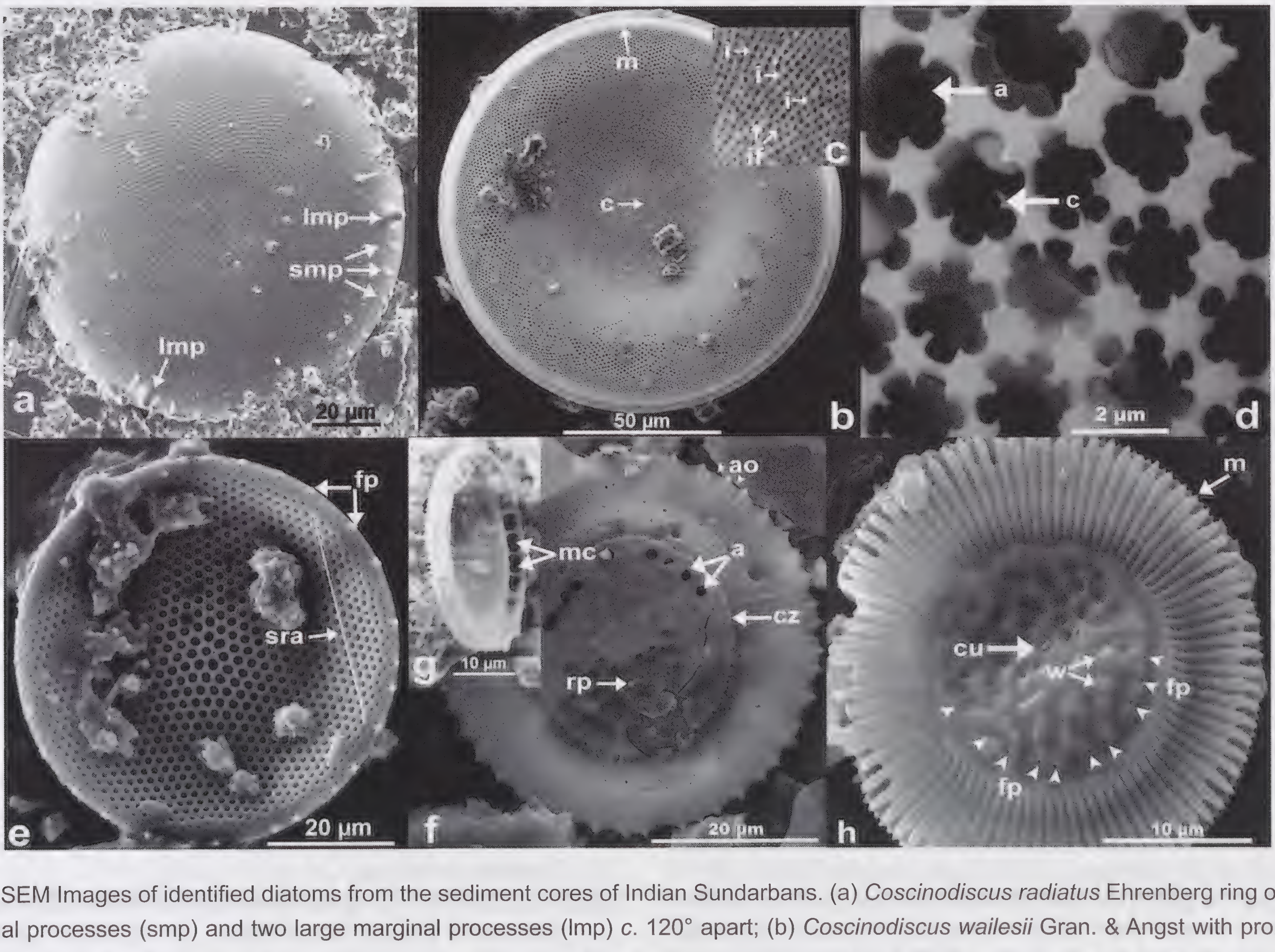

Fig. 4: SEM Images of identified diatoms from the sediment cores of Indian Sundarbans. (a) *Coscinodiscus radiatus* Ehrenberg ring of small marginal processes (smp) and two large marginal processes (lmp) *c.* 120° apart; (b) *Coscinodiscus wailesii* Gran. & Angst with prominent central hyaline area and high steep mantle bordering the valve face (m); (c) inset showing magnified portion with wide radiating interstriae (i) and rows of irregular fasciculation (if); (d) *Coscinodiscus wailesii* Gran. & Angst with 3D wall structure details showing circular areolae (a) and typically floret-shaped cribrum (c); (e) *Thalassiosira tenera* Proschkina-Lavrenko showing a complete row of marginal fultoportulae (fp) and straight rows of areolae (sra); (f) *Cyclotella striata* (Kutz.) Grun. showing slightly undulated central zone (cz) with a single rimoportula (rp) and a number of areolae (a), marginal zone with interstriae, 2–4 of which create an alveolus opening (ao); (g) *Cyclotella striata* (Kutz.) Grun. internal valve face showing marginal chambers; (h) *Cyclotella litoralis* Lange & Syvertsen showing pronounced central undulation (cu) and numerous warts (w), 10 fultoportulae (fp) and margins without chambers

cocconeiformis Grun. It was reported as part of the marine and brackish diatom assemblages of Nanaura mudflats in Japan (Park *et al*. 2012). Rashid (2014) reported it as a diatom fossil species in marine mud facies in Holocene sediment samples collected from Dobadia, Bangladesh. The species is reported to co-occur with *Coscinodiscus radiatus* and *Cyclotella striata*, which match our assemblage, and all these species are referred to as diatom fossils. Also found in this assemblage are pollen grains of mangrove *Xylocarpus* sp. and *Lumnitzera racemosa*, which according to Rashid (2014) suggests that the mud was deposited in an intertidal mudflat. Interestingly, this sampling site is situated near Dhaka, which is central Bangladesh and part of a large upland tract with an elevation of about 1.2 m called Madhupur tract. Such facies association and distribution, i.e., mud facies in central Bangladesh having evidence of deposition in coastal Bangladesh, is attributed by Rashid (2014) primarily to tectonic activity and environment of deposition.

The diatom assemblages in the sediment profiles at the sampling sites in the present study suggest the presence of a freshwater environment at some point of time during the genesis of this deltaic region. This could have been possible with greater freshwater influx during that particular period. This substantiates the findings of Morgan and McIntire (1959), Naskar and Guha Bakshi (1987), Dasgupta *et al*. (2012), which emphasize that owing to tectonic movements, a very slow tilting of the coast in the north-western part of Sundarbans (an area which lies in India) is observed. Simultaneously, the same factor has led to subsidence in the eastern part of Sundarbans (an area which lies in Bangladesh). The cumulative effect is seen today as comparatively less freshwater influx and increased salinity in the western part of Sundarbans.

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A NEW SPECIES OF THE GENUS *LEMBA* HUANG, 1983 (ORTHOPTERA: ACRIDIDAE: OXYINAE) FROM THE STATE OF MEGHALAYA, NORTH-EAST INDIA

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A new species, *Lemba elongata* sp. nov. of the subfamily Oxyinae from Meghalaya, a north-eastern state of India, has been reported for the first time. The species was observed on *Cynodon* grass. In addition to conventional morphological characters, genitalic structures are also studied.

Key words: Acrididae, Oxyinae, *Lemba*, new species, Meghalaya

INTRODUCTION

Orthoptera is one of the largest orders of insects with 26,690 valid species around the world. Of these, 1,033 species belonging to 398 genera under 21 families are known from India (Shishodia *et al.* 2010). Superfamily Acridoidea, species of which are commonly known as locusts and grasshoppers, is well-known. The members of this superfamily possess antennae shorter than the body, three-segmented tarsi, and show maximum diversity with 11 families, namely Acrididae, Dericorythidae, Lathiceridae, Lentulidae, Lithidiidae, Ommexechidae, Pamphagidae, Pamphagodidae, Pyrgacrididae, Romaleidae, and Tristiridae. Out of these 11 families, Acrididae is widely distributed in India. Many species belonging to the family Acrididae cause considerable damage to agricultural crops, pastures and forests and are notorious for their destructiveness all over the world.

Oxyinae is one of the most important and diverse subfamilies of Acrididae (Tandon 1988; Usmani and Shafee 1984, 1985). Members of this subfamily are small to medium-sized, found mostly in paddy fields and on grasses. They are rich in protein and used as food for poultry (Das *et al.* 2012).

Huang (1983) erected the genus *Lemba* with *L. daguanensis* as type species which closely resembles *Caryanda* Stål, 1878, except for the differences in the prolonged subgenital plate of the male. Later, Yin and Liu (1987) described *L. bituberculata* and Niu and Zheng (1992) described *L. viriditibia* from China. *L. sichuanensis* was described by Ma *et al.* (1994) and *L. yunnana* by Ma and Zheng (1994) from different provinces of China. Recently Ingrisch *et al.* (2004) described *L. motinagar* from Motinagar forest, Meghalaya, India. In the present work, extensive survey of the north-eastern states of India revealed a new species, *Lemba elongata* sp. nov. from Tyrsad, Shillong, Meghalaya, India.

Meghalaya is a small state in north-eastern India situated on a hilly strip extending about 300 km long (east-west) and 100 km wide, with a total area of about 22,429 sq. km. The state is bounded on the north and east by Assam, and by Bangladesh on the south and west. With an average annual rainfall as high as 1,200 cm in some areas, Meghalaya is the wettest place on earth. The western part of the plateau comprising the Garo Hills Region has lower elevations and experiences high temperatures for most of the year. The Shillong area, with the highest elevations, experiences generally low temperatures. The maximum temperature in this region rarely goes beyond 28 °C, whereas sub-zero temperatures are common in winter. About one third of the state is forested. The forests of Meghalaya are notable for their diversity of mammals, birds, and plants. Meghalaya predominantly has an agrarian economy. Around 80% of the total population of Meghalaya depends upon agriculture for their living. Meghalaya does not receive evenly distributed rainfall. Hence, the vegetation varies from tropical to temperate.

MATERIAL AND METHODS

Grasshoppers were collected using nets and killed in bottles lined with cotton soaked in cyanide. Specimens were relaxed, stretched, pinned, and labelled indicating the reference number, locality, date of collection, and name of host plant. Later they were identified using Stereozoom microscope. For the confirmation of the species permanent slides of genitalic structures were prepared by dissecting out the male and female apical parts and boiling them in 10% potassium hydroxide (KOH) solution to remove unsclerotized and non-chitinous tissues. The preparations were thoroughly washed in tap water for complete removal of KOH and examined in 70% ethyl alcohol on a cavity slide.

The material was dehydrated using increasing grades of alcohol (70%, 80%, 90%, 95% and absolute alcohol), cleared in clove oil and mounted on cavity slides in Canada balsam. Slides were examined under the microscope and drawings were made with the help of Camera Lucida. Descriptions of phallic complex follow the terminology used in Dirsh (1956). Measurements were taken with the help of Aero Space digital Vernier Calliper. Collections were stored in boxes with naphthalene balls and in plastic vials in 70% ethyl alcohol.

RESULTS

A new species, *Lemba elongata* sp. nov. of the subfamily Oxyinae was described from Meghalaya state of India, collected from *Cynodon* grass.

Lemba elongata sp. nov.

Diagnosis: Holotype male (Figs 1–2)

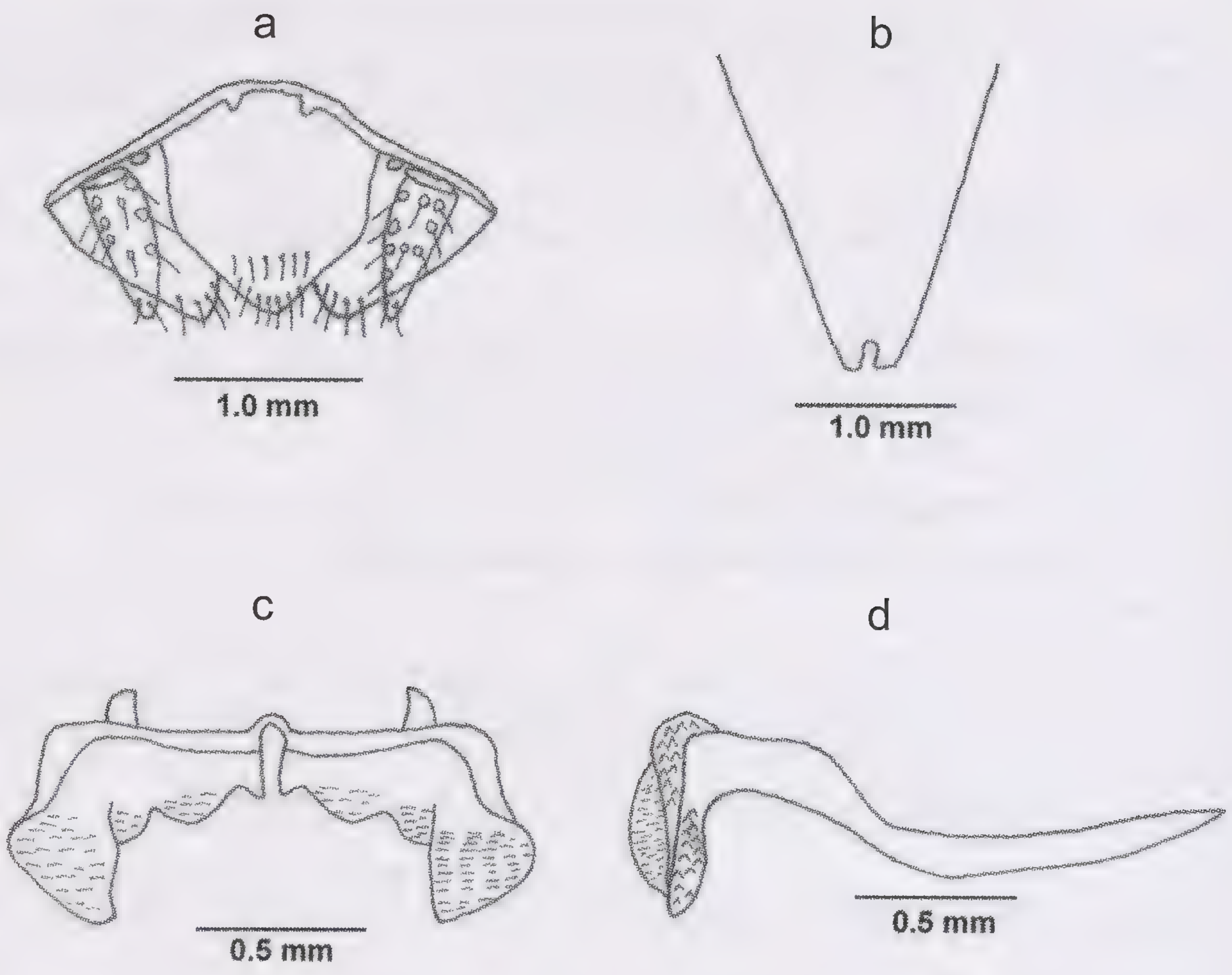

Fig. 2: *Lemba elongata* sp. nov. a: Supra-anal plate. b: Subgenital plate. c: Epiphallus. d: Aedeagus

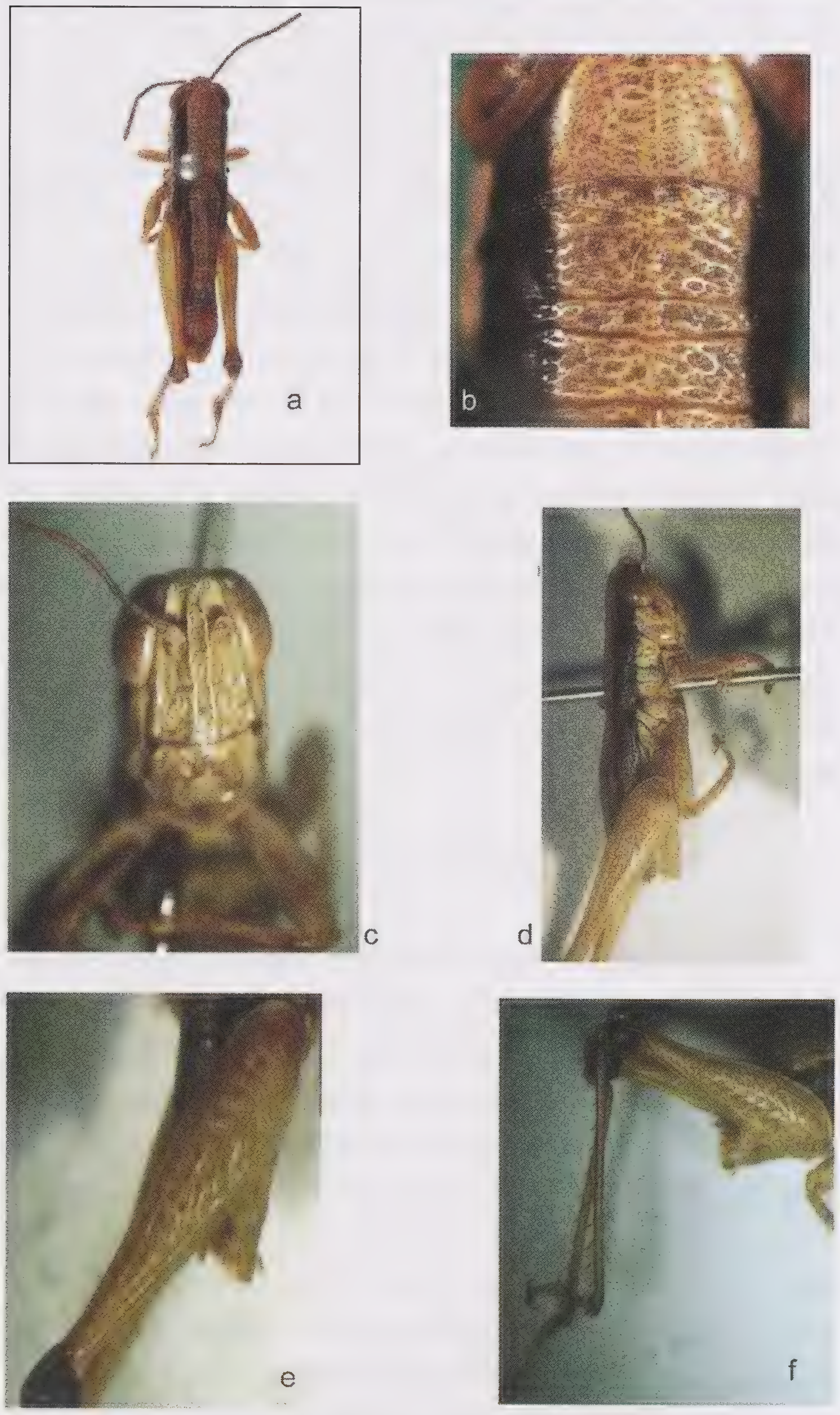

Fig.1: *Lemba elongata* sp. nov. a: Entire Male. b: Pronotum. c: Ventral view. d: Lateral view e: Hind femur. f. Hind leg

Body medium sized; head conical; fastigium of vertex short, rounded, separated from vertex by a shallow depression; frontal ridge distinct but subobsolete at clypeo-frontal suture; interocular distance longer than subocular furrow; pronotum rugose, disc with lateral angles rounded into lateral lobes, posterior margin obtusely excised; prosternal process slightly compressed, conical, apex acute; mesosternal lobes longer than wide, metasternal lobes contiguous; tegmina covering tympanum and without a series of regular, parallel, transverse stridulatory veinlets on radial area; hind femur moderately slender, dorsal carina smooth and terminating in small ventral genicular lobe terminating in a spine; hind tibia with dorsal margin not angular but rounded with eight external and twenty internal spines at dorsal margin; apical spines present on both sides.

Genitalia: Supra-anal plate broad, slightly longer than wide, lateral margins diverging apically, apex bluntly rounded. Cercus broad and slightly narrowing apically, twice as long as wide, slightly excurved, apex acutely rounded. Subgenital plate triangular with a notch medially. Epiphallus bridge divided, ancorae short, apex pointed. Aedeagus apical valve long and narrow, longer than basal valve, apex pointed, basal valve moderately broad.

Coloration: Green with black lateral margins on pronotum generally but colour changes to yellow on change of food from green habitat to dry grasses.

KEY TO THE SPECIES OF THE GENUS *LEMBA* HUANG, 1983 RECORDED FROM NORTH-EASTERN STATES OF INDIA

1. Lateral margins of supra-anal plate almost parallel and apex of cercus conical; lateral margins of subgenital plate parallel in basal half diverging apically with apex long and bifurcate; lophi broad with apex pointed,

ancorae short and broad with apex blunt; aedeagus with apical valve very long, apex blunt, much longer than basal valve, basal valve very long and broad ....*Lemba motinagar* Ingrisch *et al.* 2004

— Lateral margins of supra-anal plate diverging in the middle and apex of cercus acutely rounded; subgenital plate triangular with a notch apically; lophi broad with apex bluntly rounded, ancorae short, apex pointed; aedeagus with apical valve long with apex pointed, longer than basal valve, basal valve moderately broad.................................... *Lemba elongata* sp.nov.

Female: Not found.

Type Material: Holotype ♂, Meghalaya: Shillong, Tyrsad, 24.x.2009, on *Cynodon dactylon*, Coll.: M.I. Khan. Deposited at Zoological Museum, Department of Zoology, Aligarh Muslim University Aligarh, India (ZDAMU).

Host: *Cynodon dactylon* (L.) (Family Poaceae).

Measurements: Body length 15.32 mm, Pronotum 1.34 mm, Hind femur 9.76 mm.

Etymology: The name of new species is derived from its elongated subgenital plate.

DISCUSSION

Except for sporadic reports, there has been no systematic study on the locusts and grasshoppers belonging to the family Acrididae from the north-eastern states of India, a hotspot of biodiversity (Usmani and Khan 2010). The new species closely resembles *L. motinagar* Ingrisch *et al.* (2004), but differs from it in having divergent lateral margins in middle of supra-anal plate and acutely rounded apex of cercus.

ACKNOWLEDGEMENTS

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■ ■ ■

REVIEWS

1. NATURE WITHOUT BORDERS edited by Mahesh Rangarajan, M.D. Madhusudan, and Ghazala Shahabuddin. 2014. Published by Orient Blackswan Pvt. Ltd, New Delhi. Size: 21.5 cm x 14 cm. 270 pp. Price not stated. Hardbound.

doi: 10.17087/jbnhs/2015/v112i2/104928

What an appropriate title! Except for physical and environmental barriers, Nature has no borders. If we look at a picture of the Earth from the mesosphere, which is quite easy now due to satellite and google pictures, only the physical features of the Earth will be seen: the outlines of the land mass, islands, maybe mountain chains, vast oceans, but no man-made border. To see the man-made borders, we have to *come down* to much lower levels – physically, figuratively, and allegorically. Some borders, like India-Pakistan or USA-Mexico, can be seen from aircraft from 9,144 m to 10,668 m as a thin line, reminding us of the cupidity of human beings. If we come still lower, we can see the fenced countryside, in Europe, South Africa, and now increasingly in India. There is a popular saying that "good fences make good neighbours", but for me a fence is an indication of human failure. It shows that we have not learnt to live as a community and we have not learnt from Nature which does not have fences or borders.

When all three editors are well-known wildlife experts, thinkers, and writers, the result has to be good. It shows in the quality of chapters in this book. Besides a very informative 40 page Introduction, the editors have selected essays from experts in different fields, covering diverse subjects from the fauna of the River Ganga to urban forests, to interactions of pastoralists of the Deccan with Grey Wolf. All eight chapters are a delight to read and to learn from them. Each chapter has endnotes which have full references, or only the name of the first author. This creates confusion. At the end of the book, a consolidated Bibliography is given, which has all the references in full.

For me, establishment of "protected areas" which largely exclude human beings, shows our failure to live sustainably and in harmony with nature. That is why, to assuage our guilt, we tend to set aside a few areas free from human exploitation, demographic expansion, and economic development. We develop borders to confine Nature in selected areas. This approach may work in a few areas, for a few habitats, and for a few species, but for the majority of species, ecosystems, and biological communities it is now increasingly proved that the protected area approach may not work in the long term. Nature is beyond borders, as has been shown in the article by K.S. Gopi Sundar on Sarus Crane, and by Nitya Sambamurti Ghotge and Sagari R. Ramdas on Grey Wolf of the Deccan Plains. Snow Leopard further proves that for conservation to work, we have to develop a landscape approach paradigm where local communities become an integral part of conservation and sustainable development.

The Indian Wildlife Protection Act and Forest Conservation Act were drawn up keeping in mind forest wealth and forest-inhabiting species, particularly megavertebrates. All the articles of these acts talk about regulations and exclusion (of human beings). There is not much scope for collaboration, coexistence, and sustainability. These acts have shown good results for some species and some habitats, so most people believe that they are good for landscape level also, but this is a false notion. Strict implementation of the Wildlife Protection Act (amended in 2006) has created huge problems for local people in many so-called protected areas, so much so that people have turned hostile to wildlife conservation. When in a Lesser Florican Sanctuary, for instance, a farmer cannot sell his own land, or one has to make numerous visits to a forest officer for permission to repair a school wall, do we expect that the people will support conservation? First we declare a sanctuary in private land without consulting the owners, and then we implement laws that were essentially made for forests and forest-dwelling animals. No wonder we have so many conflicts in such protected areas.

Fortunately, there is a new crop of young conservationists who work with local communities across a large landscape canvas. As Gopi Sundar has written (page 88) "Reserved forests, national parks and wildlife sanctuaries are seen as synonymous with wildlife or with ecological integrity and biological diversity. It is only very recently that appreciation for the high degree of species persistence in agricultural areas has begun to exist."

Reading this book has further strengthened my view that either we need to amend the Wildlife Protection Act to make it more people-friendly, or we need another law for large landscape sanctuaries where local people are a part of the solution of conservation problems. This book is very timely. My only worry is that decision makers and politicians may not read it. They largely remain within the borders of their bereft intellectualism.

■ ASAD R. RAHMANI

2. THE ANNOTATED MALAY ARCHIPELAGO by Alfred Russel Wallace. Edited by John van Wyhe. 2015. Published by NUS Press, National University of Singapore, Singapore. Size: 23 cm x 15 cm. 801 pp. Price not stated. Paperback.

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I am a strong believer of evolution, so Charles Darwin and Alfred Russel Wallace are my two favourite authors and ideals. I had read Darwin's THE ORIGIN OF SPECIES, THE DESCENT OF MAN, AND SELECTION IN RELATION TO SEX, and THE VOYAGE OF BEAGLE, by the time I was 18. But I did not have the opportunity to read much about Darwin's contemporary Alfred Russel Wallace.

Like me, John van Wyhe is a fan of Wallace. His 38-page Introduction sets the context and tone of this magnum opus. Wyhe's meticulous research of old records removes many misconceptions about the Darwin-Wallace relationship; both these naturalists emerge as outstanding scientists who respected each other's contribution to the theory of natural selection.

Despite the fact that a lot of Wallace's notes and specimens were lost or destroyed in fire, there is enough material to prove what an exceptionally keen observer, writer, and chronicler he was. For example, Wallace recorded details of vocabularies of local languages which he sent to an elderly expert on the region, who lost the manuscript. Similarly, many notebooks on his stay in Singapore and Malacca are also missing. Unfortunately, many letters that he wrote to Darwin also did not survive.

Throughout his voyage, Wallace would send to UK consignments of specimens for sale. It was the golden period of exploration and specimen collection of exotic and new species, so his specimens were bought up by museums and private collectors. Fortunately, the specimens have survived and now the largest collection of Wallace's specimens is in the Natural History Museum, London.

Although 90 per cent of the book covers Wallace's writing, credit should also go to Wyhe for his excellent editing and giving perspective to the author's field notes. Without the footnotes and references provided by Wyhe, it is not easy to understand the importance of Wallace's Journal.

When the MALAY ARCHIPELAGO was first published in 1869, it was an instant success. As Wyhe writes, more than 50 reviews appeared between 1869 and 1873. It has been translated into at least 10 languages, and the German edition appeared in 1869, the year of the book's publication. The latest edition, in Italian, came out in 2013. Wyhe writes "The MALAY ARCHIPELAGO has inspired generations of explorers and biologists to study and appreciate the diversity and complexity of this fascinating region of the world." Sadly this region has seen the highest rate of destruction of forests and its native culture, which Wallace described so lovingly.

By reprinting Wallace's stupendous work, the University of Singapore and editor John van Wyhe have done yeoman service to humankind. I recommend this book to all naturalists and natural history writers. As Wyhe has concluded in his Introduction "Wallace's great work will no doubt continue to captivate and inspire readers for the foreseeable future." I cannot agree with Wyhe more. By reading MALAY ARCHIPELAGO I have filled a vacuum in my life.

■ ASAD R. RAHMANI

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MISCELLANEOUS NOTES

1. FIRST RECORD OF THE HIMALAYAN WOLF *CANIS HIMALAYENSIS* FROM BANIYA KUND, KEDARNATH WILDLIFE SANCTUARY, UTTARAKHAND, INDIA

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On May 17, 2015 at 13:50 hours, the Himalayan Wolf *Canis himalayensis* was spotted at Baniya Kund near Chopta in Kedarnath Wildlife Sanctuary, Uttarakhand, India. The wolf was spotted under the canopy on an elevation, glancing down at the road. On seeing us, it stared right back and was not alarmed, though a horn made it scamper uphill. Sheila Castelino photographed the wolf which helped confirm the presence of this species in the region (Eds: photographic evidence provided). The first sighting in this region was reported by Marina Vukovic and Anant Singh during a similar photographic excursion in April 2013 led by Nitin Bhardwaj. Since no images were available then, the reported sighting could not be confirmed.

Knowing that the wolf had gone along a waterfall, it was assumed that it would reappear, looking for some washed out rodents or meat since it had rained heavily the previous night, filling the waterfall. The wolf reappeared a few hundred metres upstream at 13:57 hrs and we got a full body photograph which helped Dr. Y.V. Jhala of Wildlife Institute of India to confirm that this indeed was the Himalayan Wolf. The photographs also show that the wolf had injuries on his front right leg.

2. ADOPTION OF POWER TRANSMISSION TOWERS AS NIGHT REFUGE BY GREY LANGUR *SEMNOPITHECUS ENTELLUS*

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Grey Langurs occur in a wide range of habitats in peninsular India, e.g., forests, villages, towns, and cultivated fields preferably close to water. The species has been recorded at many places in such suitable habitats in Chhattisgarh. It is not uncommon to see them climbing their favoured trees in the evening, preparing to roost for the night (Dunbar Brander 1982; Gee 1992; Jerdon 1989; Johnsingh and Manjrekar 2013; Lydekker 2005; Osmaston and Sale 1989; Peacock 1985; Prater 1971; Sterndale 1982).

Commonly a troupe may roost, while one of them settles at the top of the tree, at a vantage point to perform sentry duty. This individual may be replaced by another member of the troupe after a few hours. This behaviour has been observed during daylight hours. However, with the fragmentation of forests and loss of tall trees, Grey Langurs are shifting to urban areas, where they become susceptible to electrocution (Dunbar Brander 1982; Gee 1992; Jerdon 1989; Johnsingh and Manjrekar 2013; Lydekker 2005; Osmaston and Sale 1989; Peacock 1985; Prater 1971; Sterndale 1982).

Due to this, Langurs have begun to adopt to some interesting changes in habits. A change was observed at village Kukda (20° 44′ 10″ N; 81° 57′ 2″ E), district Gariaband, Chhattisgarh, on September 15, 2015. During a visit at 16:30 hours, langurs were seen feeding on trees, and at dusk they started reaching a power transmission tower about 30 m high, located about 50 m from River Pairy. This site is located in a forest along the river.

At dusk, the whole troupe of 12, including their young, climbed up to the second storey of the tower. Out of these 12 individuals, four climbed to the third storey, one of them on the fourth and the last adult langur climbed up to the top of the tower, at a height of about 30 m to act as a sentry. By 17:40 hours, the roosting arrangements seemed complete (Eds: photographic evidence provided).

The above observation suggests change in roosting site from tall trees to a tower, which incidentally was the highest available site in the area, much higher than the tallest forest trees (13–15 m) in the vicinity (Sagreiya 1982) (Eds: photographic evidence provided).

While the surrounding forest had predators like leopards though occasional, wolves and hyaena, none of these species could climb up the tower, so it is interesting that the langurs chose the tower, located in a forest, as a night refuge in place of the tall trees available, that too despite the prevailing danger of electrocution.

A similar observation was noted on January 31, 2016, when more langurs compared to the earlier observation were seen on towers at 17:20 hours near Gidhwa village (21° 50′ 25.6″ N; 81° 46′ 29.9″ E). Again, one langur settled at the top of the tower, confirming the adoption of power transmission towers as roosting sites.

Such roosting sites of langurs have not been recorded in the literature perused.

ACKNOWLEDGEMENTS

Thanks to Mr. Akhilesh Bharos (Gidhwa area), Suraj and Deependra Diwan (Kukda area), for taking timely photographs of the event despite fading light.

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3. TUBEWELL PITS AS DEATH TRAPS FOR ANIMALS: A CASE STUDY IN ALWAR DISTRICT, RAJASTHAN, INDIA

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Introduction

Rajasthan, the largest state of India in terms of geographical area, suffers from water scarcity during most of the year, though the southern part receives higher rainfall than the rest of the state. This scarcity directly affects agriculture on which the majority of the population depends.

In ancient times, major sources of irrigation were rainfall, ponds, dams, buckets, and wells, but today many modern irrigation devices like drip irrigation, sprinkler, centre pivot, lateral move, and tubewells have been developed to facilitate irrigation and increase food grain production.

The use of tubewells for irrigation is a common practice among the farmers of Rajasthan. To make a tubewell, a pit, generally 1.5 × 1.5 m cross section is dug. The depth of the pit varies from 4.5 m to 6.0 m, sometimes even more according to depth of the local water table. The pit helps to decrease the cost of boring operation, as the boring operation can begin from the bottom of the pit. A steel pipe is lowered into the freshly made bore hole to maintain its original shape if the upper strata are very loose in texture. The excavated pit is kept *kaccha* and no parapet wall is made at the mouth of the pit.

The uppermost 2.0 m depth of the pit is generally occupied by Bank Myna *Acridotheres ginginianus* for nesting. These birds excavate nest holes in the walls of the well. Sometimes their nest holes are encroached upon by

Blue Rock Pigeon *Columba livia* and Spotted Owlet *Athene brama* (unpublished information).

These tubewell pits are left unattended by the farmer, not only when the tubewell is functional but even after it is abandoned. The tubewell pit is not refilled even after the well runs dry. In due course, various plants like *Cynodon dactylon*, *Withania somnifera*, *Saccharum munja*, *Acacia nilotica*, and *Morus alba* grow on the berm of the pit and on excavated soil. Open tubewell pits, lacking parapet walls, take a heavy toll of many small nocturnal terrestrial animals and even of diurnal animals.

The present study was conducted in Alwar district of Rajasthan to evaluate the effect of tubewell pits on field-dwelling animals.

Study area

Alwar district (27° 4′–28° 4′ N; 76° 7′–77° 13′ E), located in north-east Rajasthan covers 7,83,281 hectares. The average rainfall of the district over the last ten years was recorded as 724 mm. This district plays an important role in the agricultural production of the state. About 5 lakh hectares is cultivated, wherein 83% area is irrigated and the remaining 17% is unirrigated. Irrigation is mainly done by wells and tubewells. About 2 lakh hectares are irrigated by tubewells, while about 2.6 lakh hectares are irrigated by wells in the district. The main crops are Bajra, Maize, Jowar (Millets), kharif pulses, Guar, Cotton, Arhar (Pigeon pea) and Groundnut (Mishra 1984).

Material and Methods

The present study was conducted during the rainy season (July–October) of 2011 and 2012, because this is the reproductive season for many species, especially herpetofauna which become quite active during these days. Surveys were conducted in the early morning hours to avoid human disturbance. Mornings with downpour were avoided during surveys. Every pit was monitored carefully. Powerful torchlight was beamed to observe the floor of the pits carefully. Deep pits were surveyed by climbing down into the pits with bamboo ladders. Species of animals that had stumbled into the pits and trapped were identified and counted. Since uneven rainfall can affect animal distribution as well as their activities, chi-square test (χ^2) was applied to evaluate the difference between trapped animals of different classes in both years' surveys. Pearson product-moment correlation (r) was used to estimate whether any relationship existed between the number of tubewell pits surveyed and number of trapped animals in villages (n=11).

Results and Discussion

A total of 61 tubewell pits were observed in Mundawar, Kishangarh, and Bansure tehsils of Alwar district, wherein trapped animals were found in 44 pits (Table 1). Thirty seven animals were found in 2011 and 46 in 2012. During the two-year study, amphibians reported the highest count (40.97%), which was followed by reptiles (30.12%), mammals (27.71%), and birds (1.2%). A single case was reported in birds, i.e., *Pavo cristatus* (Table 2). The difference was found insignificant (χ^2=6.52, df=3, P=0.12) between trapped animals of different classes in both surveys. The number of trapped animals showed a significant relationship (r=0.98, n=10, P<0.0001) with the number of surveyed tubewell pits in different villages.

Many victimized animal species were found in tubewell pits during the surveys. The rainy season is an active

Table 1: Study sites, number of surveyed pits and numbers of trapped animals during the surveys in Alwar district in 2011 and 2012

Year	S. no.	Village	Tehsil	No. of pits observed	No. of pits with fallen animals	Animal found trapped			
						Amphibia	Reptiles	Birds	Mammals
2011	1	Mohammadpur	Mundawar	13	8	2	4	-	4
	2	Tatarpur	Mundawar	7	5	4	2	-	1
	3	Jindoli	Mundawar	6	5	3	4	-	1
	4	Khairthal	Kishangarh	4	4	1	1	-	3
	5	Mataur	Mundawar	3	3	2	1	-	4
			Total	33	25	12	12	-	13
2012	1	Mohammadpur	Mundawar	10	6	7	3	1	3
	2	Bijwarchauhan	Mundawar	4	4	9	2	-	1
	3	Patlia	Kishangarh	4	3	2	2	-	-
	4	Mundawar	Mundawar	2	1	1	-	-	2
	5	Renagiri	Mundawar	2	1	-	2	-	1
	6	Bansur	Bansure	6	4	3	4	-	3
			Total	28	19	22	13	1	10
			Grand Total	61	44	34	25	1	23

Table 2: Species and their number recorded in tubewell pits during 2011 and 2012

Amphibia			Reptiles			Birds			Mammals		
	Year			Year			Year			Year	
Species	2011	2012	Species	2011	2012	Species	2011	2012	Species	2011	2012
Hoplobatrachus tigerinus	1	2	*Ptyas mucosa*	3	2	*Pavo cristatus*	-	1	*Tatera indica*	3	4
Sphaerotheca breviceps	2	4	*Spalerosophis atriceps*	1	1				*Golunda eliotii*	1	1
Euphlyctis cyanophlyctis	-	1	*Eryx johnii*	-	1				*Mus platythrix*	-	2
Duttaphrynus stomaticus	5	10	*Gongylophis conicus*	1	-				*Funambulus pennantii*	-	1
Duttaphrynus melanostictus	4	5	*Naja naja*	-	1				*Meriones hurrianae*	3	-
			Lycodon aulicus	-	1				*Rattus rattus*	2	-
			Varanus bengalensis	-	1				*Hemiechimus collaris*	4	2
			Lygosoma punctata	2	3						
			Mabuya carinata	3	3						
			Calotes versicolor	2	-						
Total	12	22		12	13			1		13	10

period for most animals, mainly devoted to breeding and feeding. The absence of a parapet wall around the pits is possibly a factor for this kind of accident during night in the study area. Sometimes animals chased by a predator fell into the pits as the vegetation present at the mouth of the pit attracted them for shelter. Low visibility was also responsible for such accidents during the night. Sometimes snakes visited the pits to feed on chicks of hole-nesters like Bank Myna, Blue Rock Pigeon, and Spotted Owlet.

Since the walls of the pit are vertical, climbing out and escaping is not possible. Once an animal is trapped inside the pit, either it starves or is predated upon by another trapped predator. Winter sets in after departure of rainy season in the area. It is possible that after stumbling into the pit, amphibians can hibernate for some time inside the pit, but in these captive conditions they can't escape from the pit. Due to high moisture content and poor circulation of air, they may become vulnerable to various diseases. As time passes, these animals die due to starvation and illness.

Given below are some recommendations to minimize the "pit fall death" in tubewell pits:

- Erection of parapet wall (about 0.6 m high) on the berm of tubewells.
- Clearance of vegetation on the berm of the pits.
- Rescue activity should be performed in all the unsafe tubewell pits to save the trapped animals, almost once in a week. A team of village youths can be trained in this job.
- Erection of a ladder in slanting position inside the pit, with rough vertical arms, to facilitate easy escape of animals that can climb out.
- Refilling of pits of abandoned tubewells.
- Intensive and extensive awareness activities can minimize the loss.
- Proper surveillance is needed to launch the awareness and rescue activities.

In pitfall method, dry pits are often used as traps for animal census (Buchholz and Hannig 2009; Bury and Corn 1987; Kogut and Padley 1997). Similarly, unused tubewell pits can also be used as a census tool for small animals in those areas where they are abundant.

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4. FIRST REPORT OF BLACK BAZA *AVICEDA LEUPHOTES* FROM VIDARBHA REGION, MAHARASHTRA, INDIA

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Black Baza *Aviceda leuphotes* is a small-sized raptor with short, stout legs, and feet with strong talons. A prominent crest is a feature of these bazas. They are found in dense forest often in small groups. They are also known to spend a lot of time perching on bare branches of tall trees rising above the forest canopy. When perched, the upright crest and contrasting patterns make them difficult to miss. The male has white blotches on the scapulars and secondaries. The female has white coloration on the scapulars and more chestnut bands on the underside. Black Baza is found in the forests of South Asia and Southeast Asia and in India it is reported from Uttarakhand to Assam valley, eastern Peninsula, and the Andamans. It is a winter visitor to southern Western Ghats up to Sri Lanka, and breeds in Kerala (Rasmussen and Anderton 2012).

The area of our observation is Tadoba Andhari Tiger Reserve. Often referred to as “The Land of Tigers”, Tadoba National Park lies in Chandrapur district in north-eastern Maharashtra. In 1955, 116.54 sq. km was declared a National Park. Andhari Wildlife Sanctuary was created in the adjacent forests in 1986, and in 1995, the park and the sanctuary were merged to establish the present Tiger Reserve. The core area of Tadoba Andhari Tiger Reserve (TATR) is 625.40 sq. km and the buffer area is 1,101.77 sq. km, totalling 1,727.17 sq. km.

On April 09, 2015, during a wildlife Safari in TATR, near Kasarbodi-Shivanzari area in Kolsa range (20º 10′ 53.5″ N; 079º 28′ 35.4″ E), at 08:12 hours, the first author GB noticed one medium-sized bird perched on top of a tree. He managed to photograph the bird before it suddenly flew away. Then with the help of the photograph and field guides (Ali and Ripley 1983; Grimmett *et al.* 1999; Rasmussen and Anderton 2012), the bird was identified as Black Baza *Aviceda leuphotes*. As per eBird data, this bird was reported in southern Western Ghats from Goa to Kerala, with a few sightings from southern India. The most recent sighting in Maharashtra was reported in 1987 at Bhimashankar, Pune (Rane and Borges 1987). This bird was never noticed in the Vidarbha forest (Anon. 2009; D’ Abreu 1935). So, this rare raptor is reported for the first time from Tadoba Andhari Tiger Reserve, District Chandrapur, as well as for the first time from Vidarbha region.

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5. SIGHTING OF A JUVENILE WHITE-TAILED EAGLE AT JOR BEED CARCASS DUMP, BIKANER, RAJASTHAN, INDIA

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A juvenile White-tailed Eagle *Haliaeetus albicilla* was sighted on December 22, 2014, at Jor Beed carcass dump about 10 km from Bikaner, Rajasthan, during a BNHS camp. The bird was observed to be restless and shifted its position several times. It was observed feeding on carrion for a few minutes. The White-tailed Eagle *Haliaeetus albicilla* breeds in Europe and North Asia, and migrates southwards in winter. It is a rare winter visitor to India (Rasmussen and Anderton 2005) occurring from west and south Pakistan eastwards to Assam, Nepal, and Bangladesh. It is also recorded from Gujarat, Rajasthan, and Odisha (Manakadan *et al.* 2011). It is essentially a sea eagle, but can wander from the coast up large rivers and large water bodies (Ali and Ripley 1987; del Hoyo *et al.*1994; Manakadan *et al.* 2011).

There is only a single published record of this species from the state of Rajasthan, from Keoladeo National Park, Bharatpur (Dukes *et al.* 1975). However, there have been photographic records of a juvenile bird from Tal Chhapar Wildlife Sanctuary, in December 2012 by Gobind Sagar Bhardwaj and November 2012 by Sudhir Garg (Oriental Bird Images 2014). Also, there have been several photographic records of the bird from Jor Beed while this note was in process for publication, photographs by Sudhir Garg in December 2014 and by Koshy Koshy in March 2016.

The White-tailed Eagle requires open expanses of lake, river, and coastal water where it feeds on fish, mammals, and birds, from marine, freshwater, and terrestrial environments, (BirdLife International 2014) but is also known to feed on carrion (Naoroji 2006). It is, however, unusual for it to be spotted at Jor Beed, Bikaner, which is in arid and dry habitat. The Indira Gandhi canal which is not very far from Jor Beed could have attracted the bird and it could have come to feed opportunistically on livestock carcasses which were available in abundance, with *Aquila* eagles which were seen in good numbers at the dump. This bird was a juvenile, and young birds of large raptors are known to wander a lot in search of food.

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6. FIRST BREEDING RECORD OF SAKER FALCON *FALCO CHERRUG MILVIPES* IN INDIA

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This note summarizes findings on the Saker Falcon *Falco cherrug* breeding in 2013 and 2014 in the Tsokar basin in Ladakh region of the state of Jammu & Kashmir, India, which constitutes the first breeding record in India.

In 2013, Tsewang Rigzin (TR), Assistant Project Officer of WWF (based at Tsokar Field Station of WWF), observed a pair of Saker Falcon nesting in an abandoned nest of the Upland Buzzard *Buteo hemilasius* at the top of an old watch tower at Startsapuk tso, close to Tsokar. However, the nest could not be photographed as it was built on top of the tower and the damaged stairs prevented safe access.

Startsapuk tso (33° 14′ 55.98" N, 78° 2′ 47.60" E; *c.* 4 sq. km area) is an irregularly oval-shaped freshwater lake, situated at an altitude of 4,641 m above msl. Water is supplied to the lake from its southern and western end by Chemur and Nagchuthang, two glacial streams, respectively.

The outlet of the lake is at its northern side, from where a small stream feeds into the Tsokar tso. The lake serves as an important breeding site for several waterbird species, including Black-necked Crane *Grus nigricollis*, Bar-headed Goose *Anser indicus*, Great Crested Grebe *Podiceps cristatus*, Common Redshank *Tringa totanus*, and Brown-headed Gull *Chroicocephalus brunnicephalus*.

In 2014, the Saker Falcons appeared to have shifted their nesting site, selecting an old nest of the Golden Eagle *Aquila chrysaetos* not far from Thukjay village along Tsokar lake, that lies about 4 km north of Startsapuk tso. The eagles had been monitored during the previous three years and were known to have successfully bred in 2011 and 2012, while they appeared to have abandoned the site in 2013. In May 2014, TR had observed that the pair of Saker had taken up residence and laid four eggs in the Golden Eagle's nest.

TR also photographed the nest with 3 fledglings on July 03, 2014 (Ed: photographic evidence provided) and the falcon family was last seen at the nest on August 13. This particular Golden Eagle nest was located on a vertical rocky cliff, about 58 m above the marshy ground. It was situated close to a Thukjay village (33°22.15′N; 78°0.78′E; *c.* 4,695m above msl).

On July 11, 2014, Pankaj Chandan (PC) and Taej Mundkur (TM) visited the area, and first noticed a single chick from a distance in the nest of the Golden Eagle. Two adult falcons that were identified as Saker Falcon *Falco cherrug* (according to illustrations and descriptions provided by Grimmett *et al.* 2011) were calling and flying around. One bird flew past the nest at least once but did not land during the short observation time. PC and TM were soon joined by TR who informed them that a pair of Saker Falcon had occupied and were indeed breeding in the abandoned eagle nest.

The Saker was observed hunting for voles *Alticola* sp., pikas *Ochotona* sp., hare *Lepus* sp., marmots *Marmota* sp. and choughs *Pyrrhocorax* sp. in the open grounds in and around Tsokar tso by TR.

The arrival and departure of the Saker in Ladakh appears to be similar to that of other northern summer breeders, such as the Black-necked Crane *Grus nigricollis*. They arrive in Tsokar in March–April and leave by October–November.

Until now, the Saker was regarded as a passage migrant in Ladakh (Naoroji 2007; Pfister 2004), although Kovács *et al.* (2014) refer to the possibility of its breeding in Ladakh and in a distribution map of the species have included Ladakh within a narrow band along the northern Himalaya eastwards to central China as a breeding area, without offering any proof of the species nesting here. Elsewhere in the country, it is recorded from Jammu & Kashmir, Himachal Pradesh, Rajasthan, Gujarat, Madhya Pradesh, and Uttar Pradesh as a passage migrant or as a rare winter visitor (Naoroji 2007; Pfister 2004).

The Saker breeds across a large part of northern Eurasia, with the nearest reports from western China, Mongolia, Kazakhstan, and Eastern Russia in Asia and further westwards to the Czech Republic, Hungary, and Ukraine in Europe (BirdLife International 2014; Cramp and Simmons 1980; Dixon 2009; Snow and Perrins 1998).

The species has witnessed a population decline of about 50% during the past 20 years due to various anthropogenic activities, mainly because of trapping along the migration routes and decreased prey availability (BirdLife International 2014). Kovács *et al.* (2014) have collated extensive information that indicates a mixed trend of the breeding population across its range. Nevertheless, given its precarious current global status, the Saker is listed as Endangered (IUCN 2014) and listed in Appendix 1 of Convention on Migratory Species (CMS), of which India is a signatory and in the CMS Memorandum of Understanding on the Conservation of Migratory Birds of Prey in Africa and Eurasia (Raptors MoU) of which India is a range state. It is also listed in Appendix II of the Convention on International Trade in Endangered Species (CITES), of which India is a signatory.

The Tsokar valley lies within the Changthang Cold Desert Wildlife Sanctuary and provides an important breeding habitat for several threatened and near threatened species of birds and animals, including the Tibetan Wild Ass *Equus kiang kiang*. With the latest observations of the nesting of the Saker Falcon here for the first time in India, urgent steps are needed to ensure protection of the species and its nesting habitat in these high altitude wetlands. Surveys in other valleys in Ladakh are needed to evaluate the current status of the species in the region and identify other breeding locations that should also be protected.

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7. WHITE-BREASTED WATERHEN *AMAURORNIS PHOENICURUS* NESTING ON A TREE

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There is a large tamarind tree behind my house in Chembur, Mumbai, which is frequented by arboreal bird species. In the middle of July 2013, distinct *krr-kwak-kwak, krr-kwak-kwak* calls of White-breasted Waterhen *Amaurornis phoenicurus* were heard from a bush near the tree. This was surprising as the closest waterbody was *c.* 1 km away and the next one *c.* 3 km from this site. After a week, we spotted the waterhen in our garden, and a couple of days later, the same(?) bird was sighted again with four hatchlings walking along with her.

In August 2013, contact calls of White-breasted Waterhen were heard again, one originating from the tamarind tree and the other from the ground. Later, it was observed that the waterhen on the ground flew to a height of about 6 m to the tree, and then climbed up the tree with difficulty to join the other bird in the dense foliage, where there was a nest, a dense compact structure made of reeds. Over the days, the pair could be occasionally seen from a distance, taking turns in plucking tamarind leaves and the leaves of a large bougainvillea growing on the tree to line the nest. It was even noted that one of the birds was in hot pursuit of a crow that came close to the nest.

The tree was about 18 m, and the nest was at a height of 12 m, and about one kilometre from the nearest wetland. The White-breasted Waterhen is reported to nest either on the ground in tangled undergrowth along wetlands or in a shrub or bamboo clump up to 2 to 3 m from the ground, sometimes well away from water (Ali and Ripley 1987; del Hoyo *et al.* 1996). Hence, sighting of nesting at a height of 10 m up in a tree is a new and significant record. Probably, the loss or disturbances to the nesting habitat is responsible for this pair opting to nest so high in a tree, and this may affect the survival chances of young from such nesting sites.

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8. SIGHTING OF COMMON BLACK-HEADED GULL *CHROICOCEPHALUS RIDIBUNDUS* LINNAEUS, AND WEDGE-TAILED SHEARWATER *ARDENNA PACIFICA* (GMELIN) FROM SOUTH ANDAMAN, ANDAMAN & NICOBAR IS., INDIA

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The Andaman & Nicobar Islands, popularly known as Bay Islands, are situated in the Bay of Bengal, midway between peninsular India and Myanmar, spreading like a broken necklace in a north-south direction. These islands are located between 6º 45′–13º 41′ N and 92º 12′–93º 57′ E. The archipelago consists of 572 islands that lie 193 km away from Cape Negrais in Myanmar, 1,255 km from Kolkata and 1,190 km from Chennai. The total geographical area of Andaman & Nicobar Is. is 8,249 sq. km, and the climate is typical of tropical islands of similar latitude. It is always warm, but with sea-breezes. Andaman & Nicobar Is. constitute a globally important biodiversity hotspot. Due to isolation from the mainland, endemism is very high in all taxa including avifauna (Andrews 2001; Das 1999a, b; Rao *et al.* 1980). A total of 284 bird species were reported from Andaman & Nicobar Is., belonging to 56 families under 17 orders (Sivaperuman *et al.* 2010). As a part of major ecological studies on wetland bird communities in south Andaman, sponsored by the Science Engineering Research Board (SERB), Department of Science & Technology, Ministry of Science & Technology, and INS-Utkrosh, Ministry of Defence, Government of India, we have been monitoring this area regularly since 2012. During these surveys, we recorded two species of birds from South Andaman which are new records to the Andaman & Nicobar Is.

Common Black-headed Gull *Chroicocephalus ridibundus* Linnaeus, 1766

We sighted two individuals of Common Black-headed Gull *Chroicocephalus ridibundus* Linnaeus (Eds: photographic evidence provided) in the tsunami-inundated wetlands of South Andaman (Garacharma; 11°37′ 107″ N; 92° 42′ 437″ E) on March 10, 2015, along with a flock of Pacific Golden Plover *Pluvialis fulva* (Gmelin), Eurasian Whimbrel *Numenius phaeopus* (Linn.), Common Redshank *Tringa totanus* (Linn.), Lesser Sand Plover *Charadrius mongolus* Pallas, and Little Egret *Egretta garzetta* (Linn.). Literature review revealed that Ali and Ripley (1983), Tikader (1984), Kumar *et al.* (2005), Grimmett *et al.* (2011), and Rasmussen and Anderton (2012) have not reported this species from this archipelago and the present sighting is the first report from Andaman & Nicobar Islands.

Wedge-tailed Shearwater *Ardenna pacifica* (Gmelin 1789)

On May 19, 2015, one individual of Wedge-tailed Shearwater *Puffinus pacificus* (Eds: photographic evidence provided) was sighted at Buniyabad, South Andaman (11° 40′ 385″ N; 92° 43′ 237″ E). Its plumage was grey brown on the upperside, with entirely dark grey brown underparts. This species is a medium-sized shearwater belonging to the seabird family Procellariidae. It is sometimes referred to as Muttonbird. The Wedge-tailed Shearwater is widely distributed across the tropical Pacific and Indian Ocean between latitudes 35° N and 35° S. It breeds in oceanic islands: off Japan, Islas Revillagigedo, Hawaiian Islands, Seychelles, and off Western Australia (BirdLife International 2015; del Hoyo *et al.* 1992). Review of literature revealed that only a single individual of this species has been reported from the west coast of India (Praveen 2014), and none from Andaman & Nicobar Is. (Ali and Ripley 1983; Grimmett *et al.* 2011; Kumar *et al.* 2005; Rasmussen and Anderton 2012; Tikader 1984). The individual appears to be an accidental straggler, which landed on the South Andaman coast due to the onset of strong monsoon winds.

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9. OBSERVATIONS ON THE BREEDING OF THE BROWN FISH-OWL *KETUPA ZEYLONENSIS* IN KERALA, SOUTHERN INDIA

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Family Strigidae constitutes the true owls or typical owls which comprise *c.* 200 species of raptorial birds, having cosmopolitan distribution throughout the world (Marks *et al.* 1999). Due to their nocturnal and cryptic behaviour, the population status and basic biology of most species is largely unknown. The Brown Fish-owl *Ketupa zeylonensis* is one of the four species of fish owls found in the Indian subcontinent and distributed south of the Himalaya to Sri Lanka, Middle East, China, and Southeast Asia. It is found in many habitats including deciduous, semi-deciduous, and open evergreen forests, well-wooded lowlands and sacred groves, mostly in lowlands and up to *c.* 1,900 m above msl (Ali and Ripley 1987; Rasmussen and Anderton 2005). The global population has not been quantified, but the species is reported to be generally uncommon (Marks *et al.* 1999). Due to its extremely large range, this species is listed as Least Concern, but the population is suspected to be declining owing to continuing habitat destruction (BirdLife International 2015). Knowledge on the biology of this species is very scanty (Ali and Ripley 1987). In this note, we report nest site fidelity, nest site characteristics, nesting success, and developmental periods of the Brown Fish-owl from Kerala, southern India. These observations were made from a semi-natural area with remnants of a *Sarpa Kavu* (abode of snakes) located in Mayannur in Thrissur district, Kerala.

Brown Fish-owls were seen in the study area for the last 15 years. However, we were able to locate the first nest only in 2007. From then till 2015, we observed a total of nine nesting attempts of the species in the same nest site. The nest was a small crevice without any lining or nesting material located at the base of two large branches of a Mango tree *Mangifera indica* (10° 44′ 59.2" N; 76° 22′ 41.2" E) in all the breeding attempts. The mango tree had a height of *c.* 22 m and the nest was placed at a height of 5.2 m. The vegetation surrounding the nesting tree within 0.04 ha (11.2 m radius plot) include *Areca catechuoides* (3), *Artocarpus heterophyllus* (1), *Azadirachta indica* (1), *Cocos nucifera* (2), *Delonix regia* (1), *Dimocarpus longan* (1), *Mangifera indica* (2), *Mimusops elengi* (1), *Olea dioica* (1), *Phyllanthus emblica* (2), *Strychnos nux vomica* (3), *Tamarindus indica* (1), *Tectona grandis* (3), three unidentified tree species and a few shrub species. The nest site was located within 30 m from a pond with an area of *c.* 2.5 ha.

The breeding season of Brown Fish-owl starts from mid-November and ends by mid-April (Table 1). Only a single clutch per year was found during the nine-year observation period. Of the nine nesting attempts, in two clutches the clutch size was two (2008, 2012) and all remaining clutches had single eggs (mean=1.22±0.44). The average incubation period was 34.8±1.92 days (range=32–37 days, n=5). Nestling period ranged from 43 to 49 days

Table 1: Breeding parameters of Brown Fish-owl *Ketupa zeylonensis* in Thrissur, Kerala, southern India

Year	Breeding season	Clutch size	Incubation period	Nestling period	Nesting period	Remarks
2007	December–March	1	-	-	-	One chick fledged
2008	December–March	2	37	43	80	One chick fledged and one chick lost
2009	November–December	1	-	-	-	Egg lost
2010	January–April	1	32	49	81	One chick fledged
2011	January	1	-	-	-	Egg lost
2012	December–March	2	-	-	-	Two chicks fledged
2013	November–February	1	35	46	81	One chick fledged
2014	November–January	1	34	-	-	Chick lost
2015	January–March	1	36	-	-	One chick fledged

(mean=46±3 days, n=3). Overall nesting period from the start of incubation was 80.67±0.58 days (range=80–81 days, n=3; Table 1). The birds were very shy at the nest site and moved away from the nest on approach. The birds were found carrying fish, frogs, *Calotes versicolor*, rats, and crabs during the fledgling period. Out of the 11 eggs laid in nine clutches, 7 (63.64%) chicks were fledged. Two eggs and two chicks were lost and no observations were made on the predators.

The Brown Fish-owl is known to breed in a variety of habitats including sacred groves, and to nest in old trees like mango, fig and other large trees, or in a derelict mausoleum or similar ruins, or cleft in a rocky bank, close to water (Ali and Ripley 1987). Fidelity to a specific nest site is common in most species of owls (Marks *et al.* 1999; Newton *et al.* 2002). Since the study birds were not marked, it is not certain whether the same pair used the nest site for the entire study period. But the use of the same nest site for nine continuous years indicates probable long-term nest site fidelity in Brown Fish-owl, as reported for similar species (Marks *et al.* 1999). Moreover, Ali and Ripley (1987) also reported nest site reuse by Brown Fish-owl. Breeding season of Brown Fish-owl is reported from November to March, mainly January and February, but as late as April in Sri Lanka (Ali and Ripley 1987; Marks *et al.* 1999). The observations made during this study also fall within these periods, with the season extending from November to April.

The clutch size of Brown Fish-owl was reported as 1 or 2 (Ali and Ripley 1987; Marks *et al.* 1999). During our study, 77.77% nests had single eggs and the remaining had 2 eggs each. The exact duration of the developmental periods of Brown Fish-owl are not known till date. Ali and Ripley (1987), quoting Baker, reported the incubation period as ‘approximately five weeks’, and fledging after about 7 weeks (König and Weick 2008). Our observations show that the incubation lasts for 32–37 days and the nestling period 43–49 days, with an overall nesting period of 80–81 days. These periods are similar to those of other fish owls like Blakiston’s Fish-owl (Marks *et al.* 1999; Slaght and Surmach 2008). Due to long developmental periods, the birds were able to produce only a single clutch per year. To our knowledge, no information is available on the breeding success of Brown Fish-owl. During the nine-year study, seven out of 11 eggs laid in nine clutches reached fledging, giving a breeding success rate of 63.64%, which is similar to that of other common owl species (König and Weick 2008; Marks *et al.* 1999). The observations presented herein indicate that long-term monitoring can generate a considerable amount of valuable data on the life history of elusive species.

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10. SIGHTING OF GREY HYPOCOLIUS *HYPOCOLIUS AMPELINUS* IN NARARA MARINE NATIONAL PARK, GUJARAT, INDIA

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The Grey Hypocolius *Hypocolius ampelinus* is a small passerine bird. It is the sole member of the genus *Hypocolius*, placed in the family Hypocoliidae. This slender, long-tailed bird is found in the dry semi-desert region of northern Africa, Arabia, Afghanistan, Pakistan, and western India (Ali *et al.* 1996; Grimmett *et al.*2014; Kazmierczak 2006; Pande *et al.* 2003; Rasmussen and Anderton 2012). It forages mainly on fruits, and migrates southwards in winter (Grimmett *et al.* 2014; Rasmussen and Anderton 2012).

Grey Hypocolius is an uncommon winter migrant to Kutch only, in Gujarat. It is mainly seen in small numbers near Fulay village, near Nakhatrana in the Banni region of Kutch, India. Several papers about Grey Hypocolius from Kutch have been published in various journals (including the *JBNHS*). There is an earlier sighting record of Grey Hypocolius in 1931 in Kihim, Mumbai (Ali 1931). There is a stray report on sighting of this bird near Tarkarli in Maharashtra in the period 2011–2012 (Sinnarkar *et al.* 2013).

On February 26, 2015, around 08:00 hrs, while birding near the mangroves in Narara Marine National Park near Jamnagar (Gujarat) (22° 28′ 1.5″ N; 69° 43′ 29.1″ E), we noticed a group of three birds calling and flying into a bush. They were identified as Grey Hypocolius. The birds were not shy and were flying between and perching on the upper branches of *Salvadora persica* bushes and *Prosopis* bush. We observed and photographed them for around 20 minutes after which they finally flew out of sight. Two of them were males, and we are unsure of the sex of the third, as we did not view it clearly.

All the recent records of Grey Hypocolius in India were only from Fulay village in Kutch. Hence, sighting of Grey Hypocolius in Narara Marine National Park, Jamnagar has become very important. The approximate distance between Fulay Village and Narara NP is 147 km. We believe this is the first sighting of the Grey Hypocolius in Jamnagar area.

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11. WHITE-CAPPED RIVER-CHAT *PHOENICURUS LEUCOCEPHALUS* (VIGORS): FIRST RECORD FOR JHARKHAND STATE, INDIA

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The White-capped River-chat *Phoenicurus leucocephalus* (Vigors) is a common bird of the Himalaya and north-eastern hill states. It is an altitudinal migrant breeding above 1,800 m in the Himalaya, descending to lower elevations including plains at the edge of the mountains (Ali and Ripley 1987; Grimmett *et al.* 2011). It is a conspicuous black and rufous bird with white cap, and rufous tail with a black terminal band. It haunts streams in hills, mountains, and on the edge of the plains.

Here I report a recent observation from Sahibganj district of Jharkhand, India. On December 21, 2014, I drove from Sahibganj to Moti Jharna, a waterfall in the Rajmahal Hills, which marks the north-eastern corner of Chhotanagpur Plateau. It is a popular tourist destination with a waterfall and stream that flows to the Ganga river. It is about 12 km from Sahibganj town. From a certain point, we had to walk to reach the falls. There were Rhesus Macaques *Macaca mulatta*, which I tried to observe and also a small cave where a *sadhu* (mendicant) was waiting to receive us. Suddenly, a small bird caught my attention. It flew from a rocky edge to a shrub, when I took a few photographs with a telezoom (maximum *c.* 750 mm). Light was poor as the sun was behind the cliff where the falls are located. Somehow, I saw that a dark bird with white on its head was perched on top of a thinly foliaged shrub. On my return to Sahibganj Circuit House, I downloaded the photos and to my utter surprise found that it was a White-capped River-chat! All its characters were visible, black and rufous coloration, white cap, and rufous tail with black terminal band (Eds: photographic evidence provided). The location is somewhat midway between the towns of Sahibganj and Rajmahal. From Maharajpur village one has to drive through some degraded habitat to reach the falls (25° 12′ 26″ N; 87° 43′ 34″ E).

The White-capped River-chat was so far not recorded in the area (Ali and Ripley 1987; Grimmett *et al.* 2011). Hence, this record is apparently the first for the state of Jharkhand and also south of the Ganga river.

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12. NIGHT ROOSTING ON IRON POLES BY THE WHITE-NAPED TIT *PARUS NUCHALIS* IN UDAIPUR, RAJASTHAN, INDIA

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Sajjangarh Biological Park is being developed on the eastern outskirts of Sajjangarh Wildlife Sanctuary, Udaipur, Rajasthan. As many as 24 enclosures are in progress in the Biological Park. Except for those of two lesser cats, all the enclosures are open to the sky, including that of the Leopard *Panthera pardus*. Traditionally, leopards are kept in closed enclosures as this species has the ability to climb and escape from "open to sky enclosures" if effective devices are not installed at the top of the vertical fence. In Sajjangarh Biological Park, 77 rectangular iron poles (made by welding two iron angles face to face) with a height of 5.0 m, having cross section about 75 mm x 75 mm have been erected at the periphery of the leopard enclosure to create a 5.0 m high fence. Chain link mesh of 5″ x 5″ perforation has been warped on the vertical poles to encircle the space. A rectangular iron pipe piece of 1.5 m length is welded on the top of 63 vertical poles, providing a 45° inward slope (Eds: photograph provided). Fourteen poles have bifurcated top (Eds: photograph provided). A continuous steel sheet has been welded on all the tilted inward tilting pipes to develop an unholdable strip. The leopard can venture up to the upper tip of the vertical fence, but cannot cross the inward tilting fence at the top.

On December 09, 2013, while inspecting the leopard enclosure of the Biological Park, at about 17:43 hrs, I noticed a White-naped Tit *Parus nuchalis* clinging on the uppermost tip of a pole. The bird was entering and quickly coming out from the opening of the pole. After entering, it peeped out now and then. These movements were repeated many times by the bird. It continued these restless movements for 70–80 seconds, and finally entered the tilted part of the pole and did not return. I waited at the spot for the next one hour, till it became dark, but the bird remained inside; obviously it roosted in the pole.

The next day, December 10, 2013, I revisited the same site to observe the behaviour of the bird again. I remained at an elevated location to watch the maximum number of poles at the same time. The bird was again seen entering the same pipe. Out of 77 poles, 4 were occupied by 4 White-naped Tits, one in each pole. Only single bent poles were occupied, while bifurcated poles were avoided.

The White-naped Tit is a hole-nester and rooster. It commonly roosts in the holes and hollows of stems and branches of trees. This bird is common in Udaipur district and many other localities of southern Rajasthan. It is common in the thorny and Salar (*Boswellia serrata*) forests of Sajjangarh Wildlife Sanctuary in Udaipur district (Sharma and Koli 2014). There is a paucity of hollows in the trees on the foothills of Sajjangarh Wildlife Sanctuary (Sharma and Koli 2014), hence bird seeks to occupy unusual roost sites like poles, if the opportunity is available.

In tree hollows, thermoregulation is not a problem. The walls of tree hollows being bad conductors of heat provide better shelter against cold, but iron pipes being good conductors of the heat absorb heat from the bare tarsi and claws of the bird. Though the iron hollows are not good roosting sites, paucity of natural hollows compels the bird to do so. Similar records of roosting of this species are also available in literature (Ali and Ripley 2007).

White-naped Tit *Parus nuchalis* is an Indian endemic bird restricted to the thorny forests of northern, central, southern, and western Rajasthan (Ali and Ripley 2007; Dookia 2007; Kala 2011; Mehra 2004; Sangha 2008; Sharma 1998, 2004; Sharma and Koli 2014; Tehsin *et al.* 2005; Tiwari 2001); northern Gujarat, particularly in Kutch area (Ali and Ripley 2007; Hussain *et al.* 1992; Joshua *et al.* 2007; Tiwari 2001; Tiwari and Rahmani 1996; Trivedi 2009) and in an isolated pocket of southern India (Ali and Ripley 2007; Lott and Lott 1999; Uttangi 1995). To protect and conserve this species in nature, the importance of holes and hollows is beyond doubt. In southern Rajasthan, this species has successfully used nest boxes for breeding (J. Joshua, pers. comm. 2014). All the artificial holes and hollows in the natural habitat should be protected to conserve hole-nester birds, including the White-naped Tit. The internal and external surfaces of metallic structures which have suitable holes should be painted with safe paint to make them thermoregulation-friendly.

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13. A NEW LOW ELEVATION SUMMER RECORD OF BLANFORD'S OR CRIMSON ROSEFINCH *AGRAPHOSPIZA RUBESCENS* (BLANFORD) FROM SIKKIM, INDIA

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Blanford's or Crimson Rosefinch *Agraphospiza rubescens* (Blanford) has a relatively small range in India covering central and eastern Himalaya (Ali and Ripley 1987), however, its global range is fairly large, covering the mountains of south-west and central China (MacKinnon and Phillipps 2000). It is relatively scarce in India, with a handful of records from Arunachal Pradesh and Sikkim. Elsewhere in the Subcontinent, there are a few records from Nepal and Bhutan. Ali (1962) and Ali and Ripley (1987) stated that it is a scarce resident, subject to vertical movement, in the Himalaya from central Nepal to Arunachal Pradesh; the same range is given in Grimmett *et al.* (2011). It has seasonal vertical movement with birds coming down to medium elevations in winter.

I report here a recent observation from West Sikkim district where this bird has been recorded at a lower elevation than it is known to occur in summer. On June 15, 2014, I observed and photographed a female Rosefinch at 05:27 hrs. The location was close to Pemayangtse Guest House near Pelling (28° 18′ N, 88° 15′ E; 2,090 m above msl). The bird was feeding on the ground near a wall along the connecting road to The Elgin Mount Pandim Hotel, and occasionally flew to nearby fencing. It appeared to be a female Rosefinch. It was a uniform greyish brown or olive-brown, with lighter underparts without streaks. Its iris was brown and bill grey. While male rosefinches are normally deeply coloured birds, the females are not and hence, often difficult to identify in the field. Later on from close-up photographs, I could identify it as a female Blanford's or Crimson Rosefinch. Its rump was reddish (Eds: photographic evidence provided). Its known lower range in summer is recorded as *c.* 2,700 m above msl (Ali and Ripley 1987; Kazmierczak and van Perlo 2000), however, in winter comes down as low as 1,300 m above msl. In Bhutan, the normal summer range is from 3,200 m up (Spierenburg 2005).

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14. SAP-DRINKING BY BIRDS ON TAPPED INDIAN DATE PALM *PHOENIX SYLVESTRIS*

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The Indian Date Palm *Phoenix sylvestris* is a moderate-sized (7.5–15 m) dioecious tree native to the drier parts of the Indian subcontinent. Apart from the edible fruits, it is valued for the sap that oozes from incisions cut into the stem below the crown, which is consumed as such or processed into an alcoholic beverage or molasses. The sap is channeled through a bamboo spout (or other such structure) into a collection vessel. In this communication, I report an observation on birds feeding on the exuded sap of a tree in Vasai Fort (19° 19′ 49″ N; 72°48′ 54″ E), *c.* 48 km north of Mumbai, Maharashtra.

During my observations on February 10, 2013 from 8:00–11:10 hrs, I recorded the Black Drongo *Dicrurus macrocercus*, Rose-ringed Parakeet *Psittacula krameri*, and Common Myna *Acridotheres tristis* feeding on the sap of Indian Date Palm that was flowing through a wooden conduit into a collecting vessel. The flora in the immediate vicinity included the Red Silk-Cotton Tree *Bombax ceiba*, Flame of the Forest *Butea monosperma*, and Indian Coral Tree *Erythrina indica*, all of which were in full bloom, but were not visited by the birds. The birds were observed drinking the sap for 10 minutes before they flew away. There were at least 3–4 birds on inflorescence throughout the observation period.

This observation is interesting as the birds were tapping into a food source that would not be normally available to them, except in case of damage to the trunk due to natural causes. Ali and Ripley (1987) do not state sap consumption as a food habit of any of the birds mentioned. These species do not have the mechanism to obtain sap from tree trunks unlike some sap-sucking birds like Rufous-bellied Woodpecker *Dendrocopos hyperythrus* found in Himalaya, north-east India and Bangladesh, and North American Sapsuckers (*Sphyrapicus* sp.) which specifically drill into bark to tap the sap (Abdulali 1968; Ripley 1991).

The sap extracted from the palms is usually allowed to ferment into an alcoholic beverage by spontaneous fermentation (Barh and Mazumdar 2008), unless the sap is to be drunk as such, for which lime is put into the collection vessel to delay the fermentation process. Observations on feeding and impact of fermented food resource with alcoholic content on birds are limited (Dennis 1987; Eriksson and

Nummi 1982; Fitzgerald *et al.*1990; Mazeh *et al.*2008). We did not notice any immediate effects of toddy consumption on the birds observed. Since the sap was fresh and flowing into the vessel, it is likely that it was unfermented.

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15. THE MOUNTAIN PIT VIPER *OVOPHIS MONTICOLA* (GÜNTHER, 1864) (REPTILIA: CROTALIDAE) IN MIZORAM, INDIA, WITH A NOTE ON ITS PECULIAR BEHAVIOUR IN CAPTIVITY

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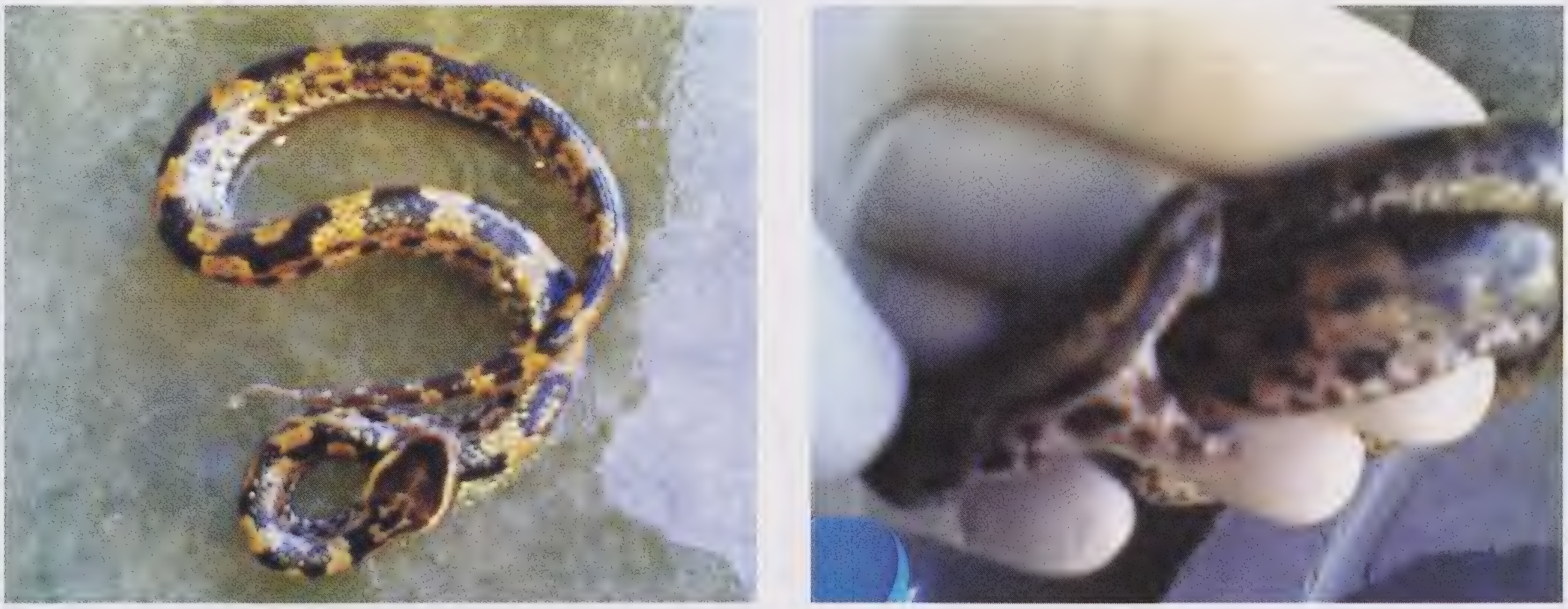
In India, the Mountain Pit Viper *Ovophis monticola* is found mostly in the Eastern Himalaya, from Sikkim, parts of West Bengal, Assam, Manipur, Meghalaya, Nagaland, and up to eastern Arunachal Pradesh. A published record from Uttarakhand needs confirmation (A. Captain, pers. comm.) Outside India, it occurs in Tibet, Nepal, China, Myanmar, Bangladesh, and Thailand (Das 2008; Gharpurey 2006; Mathew 2007; Sharma 2003; Shaw and Barker 2000; Smith 2003; Wall 2000; Whitaker and Captain 2008).

In 2002, Harit and Ramanujam (2002) documented the reptilian fauna of Mizoram state, but did not record the Mountain Pit Viper. However, the species was later recorded from Champhai district of the state (Harit 2008). The species is frequently seen during rainy season and is found on slushy



Dorsal view

Lateral view

Fig.1: *Ovophis monticola* biting its own body

wet ground of the hills, generally among the fallen leaves, tree twigs, debris, hiding under or near stones and logs. It is nocturnal and terrestrial in habit (Das 2008).

On July 12, 2013, an individual Mountain Pit Viper was caught and kept for behavioural studies in a clean transparent plastic container (11 x 9 x 3 inch) with a perforated cover for ventilation. The morphologic details of the individual were: supralabials 10, first supralabials separated from nasals, third supralabials largest, no sub-ocular shield present, two series of small scales present between eyes and supralabials, head scales smaller, inter-nasals comparatively larger than others, loreal pit present, body scalation 23:23:19, smooth, V-142, C-51 paired, A-1, eyes small, head scales unequal), and on the basis of these its identification was confirmed with the literature cited earlier in the manuscript.

The next morning, the snake was found dead, appearing to have bitten its own body (Fig. 1). Though a snake may bite itself (and other animals and handlers) when stressed and/or kept within a confined space, it usually retracts after biting, and the reason why it continued to fix its fangs on its body after biting is unclear. Whether the actual cause of death was due to the effect of the venom or due to the fangs having punctured some vital organ is unclear.

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16. FIRST REPORT OF MCADAM'S SCORPIONFISH *PARASCORPAENA MCADAMSI* (FOWLER, 1938) FROM INDIAN WATERS

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Genus *Parascorpaena* Bleeker, 1876 comprises six valid species and all are distributed in different parts of the Indo-Pacific region. The genus *Parascorpaena* differs from other genera of subfamily Scorpaeninae under the family Scorpaenidae by the presence of posterior lacrimal spine which is hooked forward, and mainly cycloid body scales (Motomura *et al.* 2009). In Indian waters, *Parascorpaena picta* (Cuvier, 1829) was reported as *Scorpaena picta* which is the only reported species of this genus from Andaman and Nicobar Islands (Ramakrishna *et al.* 2010). During a survey on "studies of ornamental fauna of the east coast of India" one specimen (SL: 108 mm) was collected by the authors from Visakhapatnam fishing harbour (17° 41′ 885″ N; 83° 18′ 143″ E), Andhra Pradesh, and identified as *Parascorpaena mcadamsi* (Fowler 1938) which is a new record from Indian waters, reported here along with its morphological characters. The specimen was preserved in 4% formalin and deposited in MARC, ZSI, Digha museum (Registration Number: MARC/ZSI/F3573). The biometrics are given in Table 1.

The taxonomic key of Poss (1999) was used for identification and the measurements and counts follow Motomura *et al.* (2009).

Table 1: Biometry of the Specimen MARC/ZSI/F3573

Proportional measurements	In % of Standard Length
Body depth	37.4
Body width	26.8
Head length	44.0
Snout length	10.4
Orbit diameter	10.2
Inter-orbital space	8.6
Head width	29.4
Upper jaw length	22.2
Lower jaw length	21.7
Pre-dorsal length	35.9
Pre-anal length	69.2
1st dorsal spine	8.6
2nd dorsal spine	11.7
3rd dorsal spine	17.2
4th dorsal spine	19.7
5th dorsal spine	19.6
11th dorsal spine	12.0
12th dorsal spine	14.9
1st anal spine	13.6
2nd anal spine	23.3
3rd anal spine	21.1
Pectoral fin length	31.7
Ventral fin length	29.5
Caudal fin length	24.9
Caudal peduncle depth	11.1
Caudal peduncle length	18.4
	In % of Head Length
Snout length	23.7
Orbit diameter	23.2
Inter-orbital space	19.7
Upper jaw length	50.5
1st dorsal spine	19.7
1st anal spine	30.8

Dorsal fin with 12 spines and 10 rays; anal fin with 3 spines and 5 rays; pectoral fin with 16 spines and pelvic fin with 1 spine and 5 rays. Small sized fish with compressed body; anterior profile arched. Mouth large, oblique; maxilla reaching posterior part of eyes; small, villiform bands of teeth present on jaw, vomer, and palatine; interorbital space concave; occiput shallow. Snout steep dorsally; nasal spines straight and upwardly directed; suborbital ridge with 3 spines, first one behind the eyes, and second and third close to each other and present posterior to eyes. Nasal spine small; suborbital spines 3, 1st one short and ventral to eye, 2nd and 3rd close together and posterior to eye. Preopercle with 4 spines and opercle with 2 spines. Lateral line scales 29; scales above lateral line 6; scales below lateral line 14. Gill rakers 13 (5+8). Body reddish in colour with irregular brown patches; under surface of the lower jaw white; all fins variegated with brown and white.

Parascorpaena mcadamsi was first described as *Scorpaena mcadamsi* from Jolo, Philippines, at a depth of 36.576 m (20 fathoms) (Fowler 1938). The characteristics of the present specimen match well with the description of the type specimen in having 3 suborbital spines, 16 pectoral fin rays, and 29 lateral line scales, which confirms the species as *P. mcadamsi.* In Indian waters, *P. picta* was reported from Andaman & Nicobar Islands (Ramakrishna *et al.* 2010). *P. mcadamsi* is the second species of the genus *Parascorpaena* reported from India. However, *P. picta* can be differentiated from the present species in many morphometric characters, i.e. having 2 suborbital spines, greater number of pectoral fin rays (usually 17, sometimes 16–18), and greater number of lateral line scales (43–49), whereas in *P. mcadamsi* there are 3 suborbital spines, fewer pectoral fin rays (15–16), and fewer lateral line scales (29–30).

P. mcadamsi is known to be distributed in the Indo-Pacific region and previously reported from Comoros, Mauritius, Mozambique, Reunion Island, South Africa, China, Indonesia, Japan, Philippines, Ryukyu Island, Taiwan, Vietnam, Australia, Fiji, French Polynesia, Marshall Island, New Caledonia, Palau, Papua New Guinea, Pitcairn, and Solomon Islands (Froese and Pauly 2014).The present note is the first report of the species from Indian coastal waters and extends the range of the species to Indian waters.

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17. HOVER-FLIES (DIPTERA: SYRPHIDAE) IN THE BOMBAY NATURAL HISTORY SOCIETY COLLECTION, WITH AN ANNOTATED CHECKLIST OF THOSE RECORDED FROM MAHARASHTRA, INDIA

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Introduction

The Bombay Natural History Society's insect collection is dominated by Lepidoptera (moths, butterflies) and Coleoptera (beetles) based on personal samplings. I was permitted to see and study the collections of two-winged flies (true Diptera) in the BNHS collection, on request, and this note documents material present on the family Syrphidae – hover-flies or flower-flies. These flies are currently recognized as valuable plant and crop pollinators, and the larvae of some of them also perform biological control of pest Homoptera (insects in agro-ecosystems in India and elsewhere). Rahmani (2014) wrote an Editorial about insects and of their important place in our ecosystems.

The BNHS collection of insects, like most other institutions in India, are composed mainly of material accumulated by foreign amateur naturalists and professional entomologists, before India gained independence in 1947. Newly collected, fresh material, sampled by Indians, is limited and dependent only on current institutional staff and their select taxa (Ghorpadé 2012; Khot 2012) mainly for their postgraduate research. There are less than a dozen specimens of hover-flies in this collection, which are identified and reported in this note. This is the next in a series of similar papers on Syrphidae in the collection of the Panjab University, Chandigarh (Ghorpadé 2014c) and Punjab Agricultural University, Ludhiana (Ghorpadé and Pathania 2014). Also tabled here is a list of Syrphidae (15 genera, 20 species) so far recorded from the State of Maharashtra, of which I document two species below as first records for this State, based on material found in the BNHS collections.

This note is dedicated to late Norman B. Kinnear (1882–1957), Curator of the Bombay Natural History Society (1907–1919) and the British Museum (Natural History), London (1920-1957) for his work on Indian wildlife, and whose writings were inspiring to the present author during his formative professional years. See also Prater (1957).

In India, except for research on economically important insects carried out in Agricultural, Veterinary and Medical institutions, there has been little interest in studying our abundant insect diversity with a basic science approach through faunistics studies, except on our butterflies which are popular and so better studied. I summarized the situation in my Editorial (Ghorpadé 2012) urging more research on our insect taxa faunistics in this country of diverse habitats.

A special publication was brought out (Anonymous 1933) on the Golden Jubilee of the BNHS, which summarized in some detail the activities of this Society. Part II dealt with the Society's magnificent *Journal* (1886–), which is in its 112th Volume currently. Scientific papers mentioned in it about Invertebrates (pp. 27–38), with an imposing 'frontispiece' photograph of the lanky naturalist T.R. Bell (see Ghorpadé *et al.* 2013 for a tribute; one Syrphidae specimen taken by him in Karachi, now in Pakistan, was found in the BNHS collection), detailed papers on all major taxa, including Diptera about which it was noted that they "deal mainly with species responsible for the spread of disease in Man and Beast in India." Then works on 'Mosquitoes and Malaria' were explained but nothing on any other family of true flies, even the hover-flies that are popular with overseas naturalists! The results of this paper will corroborate this sad lacuna below.

Information on the entomologist members of the BNHS is also available in Sálim Ali's (1979–1984) account of the founders, builders, and guardians of the Society – chief of them being E.H. Aitken, N. Annandale, C.T. Bingham, W.H. Evans, S.L. Hora, N.B. Kinnear, H. Maxwell-Lefroy, C.L.A. de Nicéville, C. Swinhoe, R.C. Wroughton, and J.W. Yerbury (*q.v.*). Insects have been a low priority, little interest focus for BNHS members until now, and the *Journal*'s Editorial Board even lacks a specialist Entomologist! I hope interest and resultant research on this massive biological group in our subcontinent will increase, since less than half of our subcontinent's probably existing species have so far been named and described, and, tragically, our indigenous natural habitats and flora are sadly being decimated along with their undiscovered fauna by current 'development' obsessed humans here, aping a commerce-ridden 'modern' Western lifestyle.

SYRPHIDAE IN THE BNHS COLLECTION

***Dolichomerus crassus* (Fabricius, 1787)**

Specimen examined: 1♀, INDIA: Maharashtra [Bombay (=Mumbai)], 19.ix.1928, Coll: P.F. Gomes.

Remarks: Stout, large black eristaline with distinct red hind femora especially, and fairly frequent in select habitats, visiting large flowers.

***Lathyrophthalmus obscuritarsis* (de Meijere, 1908)**

Specimens examined: 1♂, INDIA: Maharashtra [Bombay (=Mumbai)], 12.viii.1911, Coll: N.B. Kinnear. 1♂, INDIA: Karnataka (Mercara, Coorg), 22.x.1918, Coll: N.B. Kinnear.

Remarks: Common regular eristaline with black vittae on the mesonotum, and with rat-tailed aquatic larvae. Brunetti (1915: 230) listed this as "Bombay [*Biro*]." This species is considered a junior synonym of *megacephalus* (Rossi 1974) *vide* Dr. F.C. Thompson (*in litt.*). See also Ghorpadé (2015: 29–30)).

***Phytomia argyrocephala* (Macquart, 1842)**

Specimen examined: 1♀, INDIA: Maharashtra, D 188/24, P.G.

Remarks: Common plains eristaline earlier placed in the same genus as *Dolichomerus crassus*, with a broad black horizontal band on the mesonotum. The label is curious with no locality or date and the collector is likely to be P.F. Gomes.

***Phytomia errans* (Fabricius, 1787)**

Specimen examined: 1♀, INDIA: Maharashtra [Bombay (=Mumbai)], ??.x.1909, Coll: N.B. Kinnear.

Remarks: This is now placed in the same genus as *Phytomia argyrocephala*, but rarer, with basal half, more or less, of hind femur brownish-orange, contra all black and without prominent black markings on the mesonotum or abdomen as in *argyrocephala* (*op. cit.*).

***Syritta* sp.**

Specimen examined: 1 sex?, [damaged specimen]. INDIA: Karnataka (Mercara, Coorg), 12.x.1918, Coll: N.B. Kinnear.

Remarks: Specimen so damaged that its sex and specific identity cannot be established. This is a common smallish hover-fly that haunts drains and manure where its larvae are coprophagous or saprophagous, or feed on decaying plant material and vegetable refuse.

***Dideopsis aegrota* (Fabricius, 1805)**

Specimen examined: 1♀, INDIA: Maharashtra (Siguri), 10.iii.(?), Coll: E. Comber.

Remarks: A large, handsome predacious hover-fly with black fasciae on wings and a yellow marked black abdomen. Larvae are of unusual shape for Syrphini. Its prey were listed in Ghorpadé (1981: 70–71).

***Ischiodon scutellaris* (Fabricius, 1805)**

Specimens examined: 1♂, INDIA: Maharashtra (Ughar Lake, Bombay [=Mumbai]), 21.vi.1917, Coll: N.B. Kinnear. 1♂, PAKISTAN: Karachi, 22.ix.1903, Coll: T.R. Bell.

Remarks: The most frequent predatory hover-fly in our agro-ecosystems. Larvae are efficient predators of injurious aphids, mainly, and its recorded prey were listed in Ghorpadé (1981: 69–70). Recently recorded from Pakistan by Ghorpadé and Shehzad (2013). Deoras (1957) reported it (as "*Xanthogramma*") from the Kurla area of Bombay (=Mumbai), as identified then by specialist in the British Museum (Natural History), London.

Discussion

I found just seven species of Syrphidae, of 5 genera, in the BNHS collection, all nine specimens of these species being old specimens and have placed my identification labels on each pin carrying the fly. It is a small collection but needs to be documented as I have done in this note.

Besides the above nine specimens, one female specimen from 'Karnataka, Mercara, Coorg, 31.x.1918, N.B. Kinnear' was present in the Collection, but was in very poor condition, and I could not make an accurate identification, of the genus. It may be "*Spheginobaccha*?" then but am not sure. This is a fairly rare Microdontinae genus, unknown from below the Himalaya and NE India (Ghorpadé 2014a) and I may be wrong.

In Table I, I list all Syrphidae so far recorded from Maharashtra, 20 species of 15 genera (Ghorpadé 2014b). This is disappointing for such a large State where agriculture and horticulture is widely practiced in the countryside and on the ghats (see Ghorpadé *et al.* 2011: 84). Like this Society's collection, those of Agricultural Universities, and others, in Maharashtra need to be examined and documented, if collected and preserved in their institutional collections.

Table 1: Checklist of Syrphidae recorded from Maharashtra, India

Eristalinae [6 Genera, 10 species]	References
Monoceromyia eumenioides (Saunders, 1842)	(Ghorpadé 2014b: 8). Brunetti (1923: 38) gave "two ♀ from Matheran. Bombay Presidency, iii & v. 1899 (Nurse)"
Dolichomerus crassus (Fabricius, 1787)	BNHS collection (Ghorpadé 2014b: 8, 2015: 19–20)
Lathyrophthalmus aeneus (Scopoli, 1763)	?? (Ghorpadé 2014b: 9); Brunetti (1923: 163) as "*Eristalis taphicus*, Wied.," from "Bombay, 21.iii.1905; 2.iii.1905, on seaweed."
Lathyrophthalmus arvorum (Fabricius, 1787)	(Ghorpadé 2014b: 9, 2015: 27–28); Brunetti (1923: 183) as "It is very common apparently all over India, in hills and plains, and occurs probably in all parts of the Orient."
Lathyrophthalmus obliquus (Wiedemann, 1824)	(Ghorpadé 2014b: 9, 2015: 29)
Lathyrophthalmus obscuritarsis (de Meijere, 1908)	BNHS collection (Ghorpadé 2014b: 9, 2015: 29–30); Brunetti (1923: 191) as "Generally distributed in India from Kashmir to Bangalore . . . Dr. de Meijere described it from Singapore and Bombay."
**Phytomia argyrocephala* (Macquart, 1842)	BNHS collection, new record
**Phytomia errans* (Fabricius, 1787)	BNHS collection, new record
Eumerus aurifrons (Wiedemann, 1824)	(Ghorpadé 2014b: 11, 2015: 40); Brunetti (1923: 253) as "Bombay, 11.x.1912."
Syritta indica (Wiedemann, 1824)	?? (Ghorpadé 2014b: 13, 2015: 52–53); Brunetti (1923: 246) as "*Syritta pipiens* L." "This species is common and generally distributed in both hills and plains in India." The species identity needs to be confirmed (*indica*?) as Bombay specimens will not be *S. pipiens.* Brunetti (1923: 248) noted as "*Syritta rufifacies*, Big." "based on several in good condition in the Indian Museum from . . . Satara District . . ." The species identity also needs to be confirmed.
Syrphinae [9 Genera, 10 species]	
Serratoparagus serratus (Fabricius, 1805)	"Poona" (Stuckenberg, 1954: 413); "Igatpuri, Bombay" (Brunetti 1923: 32). Species identity of latter needs careful study of specimen, if available. (see also Thompson and Ghorpadé 1992: 15, Ghorpadé 2015: 81–82)
Allobaccha sapphirina (Wiedemann, 1830)	(Ghorpadé 2014b: 17, 2015: 85)
Asarkina incisuralis (Macquart, 1855)	(Ghorpadé 2014b: 18, 90–91); Brunetti (1923: 64, as "*ericetorum* Fabr.") as "Widely distributed in India and the East, in both hills and plains, throughout the greater part of the year."
Chrysotoxum baphyrum Walker 1849	(Ghorpadé 2014b: 18, 2015: 96–97)
Dideopsis aegrota (Fabricius, 1805)	BNHS collection; Brunetti (1923: 65) wrote: "As widely distributed as *A. ericetorum* [= *Asarkina incisuralis*] in India and the East, both from hills and plains, at almost all seasons of the year." See also Ghorpadé, 2015: 103–104.
Episyrphus viridaureus (Wiedemann, 1824)	(Ghorpadé 2014b: 20, 2015: 108–109); Brunetti (1923: 84) as "*Syrphus balteatus* De Geer," "This species is extremely common throughout the whole of the East in both hills and plains during the greater part of the warm weather."
Ischiodon scutellaris (Fabricius, 1805)	BNHS collection (Ghorpadé 1994: 6, 2015: 110–113); Brunetti (1923: 99) as "The species is common in many parts of India and Assam practically all the year round, and is one of the most widely distributed Syrphids in the East."
Macrosyrphus confrater (Wiedemann, 1830)	BNHS collection (Ghorpadé 2014b: 20, 2015: 114–116)
Sphaerophoria bengalensis Macquart, 1842	?? (Ghorpadé 1994: 13, 2015: 127–128)
Sphaerophoria macrogaster (Thomson, 1869)	(Joseph 1967 – as "*Sphaerophoria poonaensis*"; Ghorpadé 1994: 13); "Bombay Presidency" (Brunetti 1923: 103) as "*Sphaerophoria indiana* Big." Certainly misidentified for *macrogaster.* See also Ghorpadé 2015: 130

* new record for species

Though more than 75% of all our 500+ syrphid species fly in the Himalaya and in north-east India, peninsular India has 77 species (of 40 genera) documented (Ghorpadé, unpubl. data). So in Maharashtra only just over a quarter of these peninsular species have so far been recorded, which is disappointing. Incidentally, one of the first to collect Syrphidae (and other insects) from Bombay [= Mumbai] was an entomologist from Hungary, Dr. Biro.

Other than examining available collections in institutions here in Maharashtra, and in our major insect collections in IARI (New Delhi), ZSI (Kolkata), and FRI (Dehradun), I need to look at my personal collections made in the past 30+ years for specimens taken in Maharashtra, from March 1980 at Panhala and Radhanagari near Kolhapur, and in October 1984 in Borivli NP, Bombay, and also later in Matheran, and in the next three decades, last at Kolhapur in August 2016. These will be documented by me in another paper in the near future and should add more species to the Maharashtra list. Most of my Maharashtra collections have been made in and around Kolhapur, and on the ghats to its west, from Amba and Vishalgarh down south to Amboli. These collections were made in all months of the year, from March 1980 to August 2016 . Kharakvasla and Mulshi on the Pune ghats have also been sampled and areas in and around Nagpur were visited in October 2012.

Checklist of Syrphidae recorded from Maharashtra, India

The following list of 20 species (in 15 genera) documented from the State of Maharashtra so far are given below with their current binomens, authorities of species names, year of first publication and published record reference(s). Those I have found in the BNHS collection are noted, and two of these species are new records (with an asterisk mark) for this State as identified and mentioned by me in this present publication.

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18. RANGE EXTENSION OF COMMON JAY *GRAPHIUM DOSON* (LEPIDOPTERA: PAPILIONIDAE) TO GUJARAT, INDIA

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The Common Jay butterfly *Graphium doson* (C. & R. Felder) is known to occur in India, particularly in southern India up to Maharashtra, Odisha, West Bengal, Uttarakhand to Arunachal Pradesh, and the Northeast (Kehimkar 2008). Its subspecies Dakhan Common Jay *Graphium doson eleius* Felder & Felder, 1864 is distributed largely in the Western Ghats (Saji 2015). Though it is known to occur in Maharashtra, Shull (1963, 1964) did not encounter it from the nearby Dang Forest of Gujarat. Even in the recent past, it was not recorded from Vansda National Park which is a part of Dang Forest (Bhalodia *et al.* 2002). The species was listed as occurring in Gujarat (Parasharya and Jani 2007), based on a checklist of the butterflies of Western Ghats received from Dr. K. Kunte (pers. comm.) during 2007, though it is not mentioned in any other published records on the butterflies of Gujarat.

Though we had seen this butterfly at several sites around Anand, Gujarat (22° 32′ N; 72° 58′ E) while preparing the book BUTTERFLIES OF GUJARAT, we could not collect it or watch it at close quarters to confirm its identification. We were able to collect as well as photograph it from 2008 onwards. During the last seven years, we have recorded it from Anand, Kheda, Vadodara, Ahmedabad, and Gandhinagar districts of Central Gujarat. It is seen throughout the year, often flying around and laying eggs on False Ashoka tree or Mast tree *Polyalthia longifolia* – a roadside ornamental. It is quite abundant around Anand, as seen in the collections made by undergraduate students of agricultural science. Out of 800 butterflies collected by students, 3.25% were *G. doson*. One of us (BMP) had collected a dead though freshly emerged specimen below a Netted Custard Apple tree *Annona reticulata* at Rajendranagar, Hyderabad, during February 2010. This was also an important record as there are only a few records of the species from Telangana and Andhra Pradesh (Saji 2015).

Though it is known to occur in Maharashtra, particularly in northern Western Ghats, it was recorded from only four sites of the thirty sites surveyed by Padhye *et al.* (2013). Saji (2015) recorded the species' presence from eight districts of Maharashtra. Hence, its occurrence in central Gujarat, particularly up to Gandhinagar is a northward range extension of *c.* 450 km, probably aided by the presence of its larval host plants. It is quite possible that plantation of *Polyalthia longifolia* along the roadside and gardens may have played a key role in its range extension. It is also possible that with the help of such larval host plants, the species may spread further northwest, where it was previously not reported.

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19. ADDITIONS TO LARVAL HOST PLANTS OF BUTTERFLIES OF THE WESTERN GHATS, KERALA, SOUTHERN INDIA (RHOPALOCERA, LEPIDOPTERA): PART 2

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Introduction

The study of butterflies is incomplete without the documentation of their larval host plants. The earlier works in this realm were by Bell (1909–1927), Wynter-Blyth (1957), and Sevastopulo (1973), who wrote on the host plants of Indian Lepidoptera (Kalesh and Prakash 2007). After a gap of many years, works by Kunte (2000, 2006), and Kalesh and Prakash (2007) are adding new information on site-specific host plants, which is of tremendous importance for the conservation of butterflies of the Western Ghats.

In the first part (Kalesh and Prakash 2007), we had reported new records of host plants for 25 species of butterflies, especially of the southern Western Ghats. In this note, we report several additions to this ever-growing list of host plants of more than 60 butterfly species of the Western Ghats. This also includes host plant data for the narrowly endemic Travancore Evening Brown *Parantirrhoea marshalli* and Nilgiri Tiger *Parantica nilgiriensis*. The data presented here is the result of extensive fieldwork, observations, and larval rearing for the past 10 years in the southern Western Ghats. The host plant is confirmed only after successful completion of the lifecycle in all cases. The Floras referred for identification of the larval hostplants are Blatter and Millard (1997), Gamble (1967), Ramarao (1914), Ravi and Mohanan (2004), Renuka (2000), Seethalakshmi and Muktesh Kumar (1998), Sivarajan and Mathew (1997), Subramanian (1995), and Nayar *et al.* (2006). Host plant utilization was checked against Kunte (2000, 2006), Kalesh and Prakash (2007), and Robinson *et al.* (2001).

Taxonomy and scientific nomenclature of butterflies follows Larsen (1987–1988). Further additions to this larval host plant list will appear in the third part of this series.

Family Pieridae

1. ***Eurema blanda silhetana***: *Sesbania grandiflora* (L.) Poiret (Fabaceae), Vanchiyoor, Thiruvananthapuram; August 2009. New record for India; recorded in Indonesia and Thailand earlier.

2. ***Cepora nerissa phryne***: *Capparis brevispina* DC., (Capparaceae), Kumarapuram, Thiruvananthapuram; July–August 2009.

3. ***Belenois aurota***: *Capparis brevispina* DC., (Capparaceae), Kumarapuram, Thiruvananthapuram; July–August 2009.

4. ***Appias libythea libythea***: *Capparis brevispina* DC., (Capparaceae), *Cleome burmannii* Wight & Arn., (Cleomaceae), Thiruvananthapuram; July–August 2009.

5. ***Leptosia nina***: *Cleome burmanni* Wight & Arn., (Cleomaceae), Thiruvananthapuram; July–August 2009.

Family Nymphalidae

6. ***Discophora lepida lepida***: *Ochlandra travancorica* Benth. (Poaceae), Kallar valley, Thiruvananthapuram; July 2006. *Ochlandra scriptoria* (Dennst.) Fisch. (Poaceae), Kottiyoor reserve forests; October 2009.

7. ***Amathusia phidippus phidippus***: *Calamus thwaitesii* Becc. (Arecaceae), Kallar valley, Thiruvananthapuram; July 2010.

8. ***Parantirrhoea marshalli***: *Ochlandra travancorica* Benth. (Poaceae), Kallar valley, Thiruvananthapuram; July–October 2004–2011. *Ochlandra scriptoria* (Dennst.) Fisch. (Poaceae), Kottiyoor reserve forests; October 2010.

9. ***Melanitis zitenius gokala***: *Ochlandra travancorica* Benth. (Poaceae), Kallar valley, Thiruvananthapuram; October 2005. *Ochlandra scriptoria* (Dennst.) Fisch. (Poaceae), Thattekad; October 2007.

10. ***Melanitis phedima varaha***: *Spodiopogon rhizophorus* (Steud.) (Poaceae), Kallar valley, Thiruvananthapuram; October 2005. *Setaria* sp. (Poaceae), Ponmudi hills; November 2005.

11. ***Lethe drypetis todara***: *Bambusa striata* Lodd. ex Lindl. (Poaceae), Thiruvananthapuram; November 2004.

12. ***Mycalesis oculus***: *Oplismenus compositus* (L.) P. Beauv. (Poaceae), Mannavan shola, Idukky; May–June 2007.

13. ***Orsotrianea medus mandata***: *Ischaemum indicum* (Houtt.) Merrill (Poaceae), a small herbaceous grass in open places, edges of roads, Aakulam; August 2005.

14. ***Zipaetis saitis***: *Ochlandra travancorica* Benth., *Ochlandra scriptoria* (Dennst.) Fisch. (Poaceae), Kallar valley, Thiruvananthapuram; June–July 2009–2011.

15. ***Ypthima ceylonica***: *Axonopus compressus* (Swartz) Beauv. (Poaceae), a small to medium sized herb, Thiruvananthapuram; June 2005.

16. ***Charaxes solon solon***: *Pithecellobium dulce* (Roxb.) Benth. (Fabaceae), Chennai; October 2008. Recorded in Philippines as a host plant by Robinson *et al.* (2001), August 2001.

17. ***Neptis jumbah jumbah***: *Cassia fistula* L. (Fabaceae), at butterfly garden Thenmalai (=Thenmala); June 2010; *Nothapodytes nimmoniana* (Grah.) Mabb., (Icacinaceae), small tree in evergreen forest at Bonaccord in Thiruvananthapuram; May 2008.

18. ***Neptis hylas varmona***: *Urena lobata* L. (Malvaceae), a herb in disturbed areas of deciduous forests and scrubland, Thiruvananthapuram; June 2008.

19. ***Parantica nilgiriensis***: *Tylophora indica* Merr. (Asclepiadaceae), a climber, Ponmudi, Thiruvananthapuram; June 2009.

Family Lycaenidae

20. ***Acytolepis puspa felderi***: *Bridelia retusa* A. Juss. (Euphorbiaceae), a medium-sized tree at Aakulam lake, Thiruvananthapuram; June 2007.

21. ***Jamides alecto alocina***: Inflorescence of *Zingiber zerumbet* (L.) J.E. Smith (Zingiberaceae), Kallar valley, Thiruvananthapuram; June 2008. Recorded in Andamans, Taiwan, and Japan, according to Robinson *et al.* (2001).

22. ***Prosotas nora nora***: *Allophylus cobbe* Blume (Sapindaceae), shrub in coastal forests, Aakulam lake, Thiruvananthapuram; November 2009.

23. ***Anthene lycaenina lycaenina***: *Allophylus cobbe* Blume (Sapindaceae), a shrub in coastal forests Aakulam lake, Thiruvananthapuram; November 2009.

24. ***Arhopala pseudocentaurus pirama***: *Hopea ponga* (Dennst.) Mabb. (Dipterocarpaceae), large tree at Aakulam hills, Thiruvananthapuram; November 2009.

25. ***Arhopala amantes amantes***: *Hopea ponga* (Dennst.) Mabb. (Dipterocarpaceae), large tree at Aakulam hills, Thiruvananthapuram; November 2009.

26. ***Rathinda amor***: *Calophyllum inophyllum* L. (Clusiaceae), *Hopea ponga* (Dennst.) Mabb., (Dipterocarpaceae), Aakulam lake; April 2006.

27. ***Zesius chrysomallus***: *Cassia fistula* L. (Fabaceae), medium-sized tree in Thiruvananthapuram; November 2009.

28. ***Deudorix epijarbas epijarbas***: *Harpullia arborea* Radlk. (Sapindaceae), Achankovil Reserve Forest; February 2010.

29. ***Arhopala alea***: *Syzygium heyneanum* Wall. (Myrtaceae), small trees found gregariously along water course at Aaralam Wildlife Sanctuary, Kannur; January 2012.

Family Hesperiidae

30. ***Hasora taminatus taminatus***: *Derris* spp. (Fabaceae), Ponmudi hills, Thiruvananthapuram; October 2007.

31. ***Burara gomata***: *Schefflera venulosa* (Wight & Arn.) Harms and *Schefflera wallichiana* (Wight & Arn.) Harms (Araliaceae), medium-sized trees in sholas and riparian regions, Ponmudi hills, Thiruvananthapuram; Aaralam Wildlife Sanctuary; and Kalakkad-Mundanthurai Tiger Reserve; 2011 and 2012. The larvae also feed on cultivated garden varieties of the plant.

32. ***Choaspes benjaminii benjaminii***: *Meliosma pinnata* (Roxb.) Maxim., *Meliosma arnottiana* (Wight.) Walp. (Sabiaceae), Thirunelli reserve forests Wayanad, October 2009; *Meliosma pinnata* (Roxb.) Maxim., *Meliosma simplicifolia* Walp. (Sabiaceae), Shendurney Wildlife Sanctuary, June–July 2010; and *Meliosma pinnata* (Roxb.) Maxim. (Sabiaceae), Mangaladevi, Periyar Tiger Reserve, September 2011.

33. ***Celaenorrhinus leucocera***: *Strobilanthes ciliatus* Nees, and *Strobilanthes luridus* Wight. (Acanthaceae), Kallar valley, Thiruvananthapuram; June–July 2002.

34. ***Celaenorrhinus ambareesa***: *Strobilanthes ciliatus* Nees (Acanthaceae), Pampa valley, Periyar Tiger Reserve; June–July 2002.

35. ***Celaenorrhinus ruficornis fusca***: *Strobilanthes asperrimus* Nees (Acanthaceae), Ponmudi hills, Thiruvananthapuram; October–November 2002.

36. ***Coladenia indrani indra***: *Bridelia retusa* (L.) A. Juss. (Euphorbiaceae), *Thespesia populnea* (Malvaceae), medium-sized trees in suburbs of Thiruvananthapuram; June–October 2009.

37. ***Caprna ransonnetti potiphera***: *Urena lobata* L. (Malvaceae), Kallar valley, Chatancode valley, Thiruvananthapuram; June, 2004.

38. ***Aeromachus pygmaeus***: *Cyrtococcum trigonum* (Retz.) A. Camus, *Stenotaphrum dimidiatum* (L.) *Stenotaphrum secundatum* (Walter) O. Ktze. (Poaceae); small grasses at Aakulam lake, Thiruvananthapuram; July 2006.

39. ***Aeromachus dubius dubius***: *Cyrtococcum trigonum* (Retz.) A. Camus (Poaceae), small grass at Munnar, Idukky district; October 2009.

40. ***Ampittia dioscorides dioscorides***: *Leersia hexandra* Swartz (Poaceae), small grass at Aakulam Lake, Thiruvananthapuram; October 2004.

41. ***Halpe homolea hindu***: *Ochlandra scriptoria* (Dennst.) Fisch. (Poaceae), Kottiyoor Reserve Forests; October 2009.

42. ***Sovia hyrtacus***: *Ochlandra scriptoria* (Dennst.) Fisch. (Poaceae), Kottiyoor Reserve Forests; June–July 2009.

43. ***Thoressa astigmata***: *Ochlandra travancorica* Benth. (Poaceae), Kallar valley, Thiruvananthapuram; October 2006 and November 2010.

44. ***Iambrix salsala luteipennis***: *Bambusa wamin* Camus (Poaceae), a medium bamboo cultivated in gardens of residential areas in Thiruvananthapuram; December 2004.

45. ***Notocrypta paralysos alysia***: *Curcuma ecalcarata* Sivaranjan & Indu Balachandran (Zingiberaceae), Shendurney Wildlife Sanctuary, Thiruvananthapuram; June–July 2008.

46. ***Notocrypta curvifascia curvifascia***: *Curcuma ecalcarata* Sivaranjan & Indu Balachandran (Zingiberaceae), Shendurney Wildlife Sanctuary, Thiruvananthapuram; June–July 2008.

47. ***Salanoemia sala***: *Calamus thwaitesii* Becc., *Calamus hookerianus* Becc. (Arecaceae), Kallar valley Thiruvananthapuram; June–July 2006.

48. ***Udaspes folus***: *Alpinia calcarata* Rosc., *Curcuma ecalcarata* Sivaranjan & Indu Balachandran (Zingiberaceae), Shendurney Wildlife Sanctuary, Thiruvananthapuram; June–July 2008.

49. ***Suastus minuta bipunctus***: *Calamus travancoricus* Bedd. ex Hook.f. (Arecaceae), Shendurney Wildlife Sanctuary; October–November 2009–2011. *Calamus brandisii* Becc. (Arecaceae), Athirumala, Agasthyakoodam Biological Park; October–November 2006.

50. ***Baracus vittatus***: *Imperata cylindrica* (L.) P. Beauv. (Poaceae), gregarious grass at Ponmudi hills, Thiruvananthapuram; June–July 2006.

51. ***Hyarotis adrastus praba***: *Calamus hookerianus* Becc. Kallar valley, Thiruvananthapuram, 2006; *Calamus rotang* L., (Arecaceae), Aakulam lake, Thiruvananthapuram, October–November 2004.

52. ***Quedara basiflava***: *Calamus hookerianus* Becc. (Arecaceae) Kallar valley, Thiruvananthapuram, July 2003. Also fed on *Calamus rotang* L., (Arecaceae), from Aakulam lake, Thiruvananthapuram, August 2004; in captivity.

53. ***Matapa aria***: *Ochlandra travancorica* Benth. (Poaceae), Kallar valley and Shendurney; June 2005–2009. *Ochlandra scriptoria* (Dennst.) Fisch. (Poaceae), Chenganoor, Aalapuzha, July 2003.

54. ***Taractrocera ceramas ceramas***: *Axonopus compressus* (Swartz.) P. Beauv., *Oplismenus compositus* (L.) P. Beauv. *Imperata cylindrica* (L.) P. Beauv., *Miscanthus sinensis* Anderss. (Poaceae), at Ponmudi hills, Thiruvananthapuram; October 2006.

55. ***Oriens goloides***: *Oplismenus compositus* (L.) P. Beauv., *Axonopus compressus* (Swartz.) Beauv. (Poaceae), suburbs of Thiruvananthapuram; June 2005.

56. ***Telicota colon colon***: *Phragmites karka* (Retz.) Trin. ex Steud. (Poaceae), large gregarious reeds at water edges of Aakulam lake, Thiruvananthapuram; June–July 2005–2011.

57. ***Parnara bada***: *Brachiaria mutica* Stapf (Poaceae), gregarious tall grass at edges of water and in marshes, at Aakulam, Thiruvananthapuram; November 2009.

58. ***Borbo cinnara***: *Phragmites karka* (Retz.) Trin. ex Steud. (Poaceae), large reed usually seen in clumps along waterways and marshes about the lake; October 2005. *Stenotaphrum dimidiatum* (L.) Brongn., *Stenotaphrum secundatum* (Walter) O. Kuntze, (Poaceae), grass at edges of water and in marshes, at Aakulam, Thiruvananthapuram; October 2009.

59. ***Pelopidas agna agna***: *Axonopus compressus* (Swartz.) Beauv. (Poaceae), small to medium-sized grass, Ponmudi; October 2005.

60. ***Pelopidas mathias mathias***: *Axonopus compressus* (Swartz.) Beauv., *Brachiaria miliiformis* (Presl.) A. Chase, *Brachiaria mutica* Stapf (Poaceae), Aakulam, Thiruvananthapuram; June 2004. This has been recorded at Taiwan earlier by Robinson *et al.* (2001).

61. ***Polytremis lubricans lubricans***: *Imperata cylindrica* (L.) P. Beauv., *Miscanthus sinensis* Anderss. and *Brachiaria mutica* Stapf (Poaceae), gregarious tall grasses at edges of water and in marshes, at Aakulam, Thiruvananthapuram; March–April 2006.

62. ***Caltoris kumara kumara***: *Bambusa striata* Lodd. ex Lindl. (Poaceae), Aakulam, Thiruvananthapuram 2001. *Ochlandra travancorica* Benth. (Poaceae), Thiruvananthapuram; November 2000. *Ochlandra scriptoria* (Dennst.) Fisch. (Poaceae), Chengannur, Alappuzha, October 2003; Pampa valley in Periyar Tiger Reserve, December 2004.

63. ***Caltoris canaraica***: *Bambusa striata* Lodd.ex Lindl., *Bambusa arundinacea* Retz. (Poaceae), Thirunelli Reserve forests, Wayanad; October 2009. *Pseudoxytenanthera monadelpha* (Thw.) Soderstr. & R.P. Ellis. (Poaceae), Periyar Tiger Reserve; September 2011.

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20. FIRST RECORD OF *STILIGER SMARAGDINUS* BABA, 1949 (MOLLUSCA: SACOGLOSSA: LIMAPONTIIDAE) FROM INDIA

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Introduction

Evolution in the Sacoglossa is closely linked to their specialized suctorial herbivorous habit. All known shelled sacoglossans feed on algae of genus *Caulerpa* (Jensen 1997a). *Stiliger smaragdinus* Baba, 1949 is a known associate of *Caulerpa racemosa* (Baumgartner *et al.* 2009). Like many algal-feeding sacoglossans, *S. smaragdinus* is highly cryptic and almost invisible on its algal food due to the green pigments from *C. racemosa* that are retained in its digestive system, and help to camouflage it. Thus, little is known about the species due to its cryptic nature.

Stiliger smaragdinus shows wide though discontinuous latitudinal distribution along the west Pacific from Japan to Australia (Jensen 2006). There are only a few records of this species: Japan (Ichikawa 1993), western Australia (Jensen 1993), Hawaii (http://seaslugsofhawaii.com/species/Stiliger smaragdinus-a.html, 1994), northern Australia (Jensen 1997b), eastern and southern Australia (Burn 2006; Vafiadis 1999), Mariana Islands (Carlson and Hoff 2003), Tanzania to New Zealand, New Caledonia, Papua New Guinea, and the Philippines (Gosliner *et al.* 2008), and Singapore (Jensen 2009).

The present study was carried out at Poshitra (22° 25′ 2.49″ N; 69° 12′ 32.77″ E) and Narara (22° 28′ 46.33″ N; 69° 43′ 9.91″ E) in the Gulf of Kachchh, Gujarat, and Okha (69° 43′ 9.91″ N; 69° 4′41.67″ E) and Dwarka (22° 14′ 22.07″ N; 68° 57′ 21.06″ E) in the Arabian Sea, Gujarat (Fig. 1). Poshitra and Narara form an important part of Marine National Park and Sanctuary. The foreshore at Poshitra and Narara is dominated by patchy coral reef and rocky shore with abundant algal growth, while the backshore is dominated by mudflats and mangroves. Okha and Dwarka, on the other hand, are mainly rocky shores.

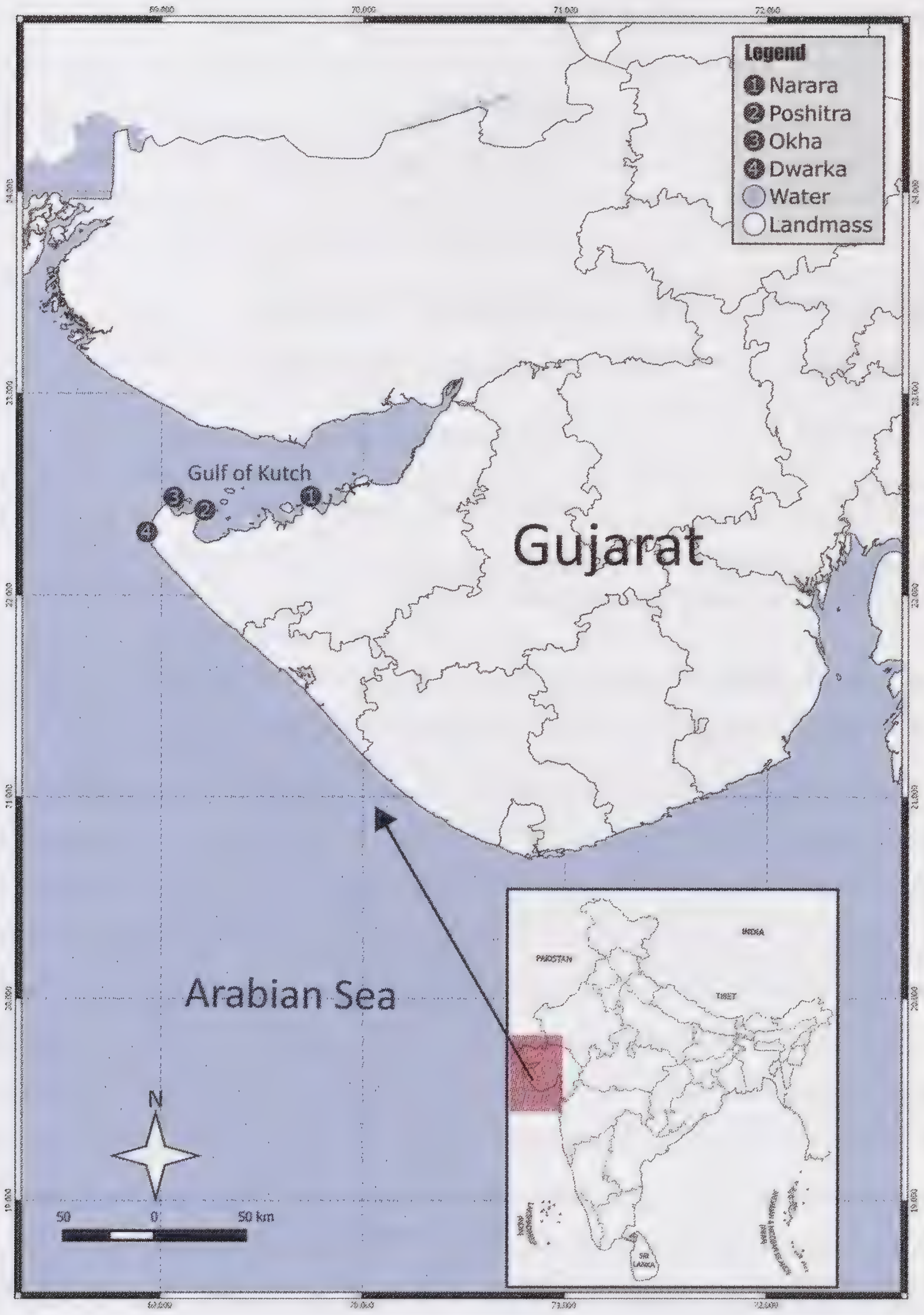

Fig. 1: Map showing area of study

Material and Methods

Opisthobranchs were collected manually in the intertidal region of Poshitra, Gulf of Kachchh, in Gujarat. Out of four specimens found during the survey, three were collected and deposited in the Bombay Natural History Society (BNHS) opisthobranch collection (BNHS-OPISTHO-972). One specimen (35 mm) was preserved in 4% Formaldehyde and the other two (15 mm and 37 mm) were preserved in 95% Ethanol. The fourth specimen (15 mm) was released back in its original habitat. Necessary permissions for the collection of specimens were procured from Marine National Park authority.

Description

SYSTEMATICS

Order: Sacoglossa Ihering, 1876

Family: Limapontiidae Gray, 1847

Genus: *Stiliger* Ehrenberg, 1831

Stiliger smaragdinus Baba, 1949 (Figs 2–4)

Synonyms

Hermaeina smaragdina Baba and Hamatani, 1970

Aplysiopsis smaragdinus Burn, 1972

Ercolanias maragdina, Ichikawa, 1993

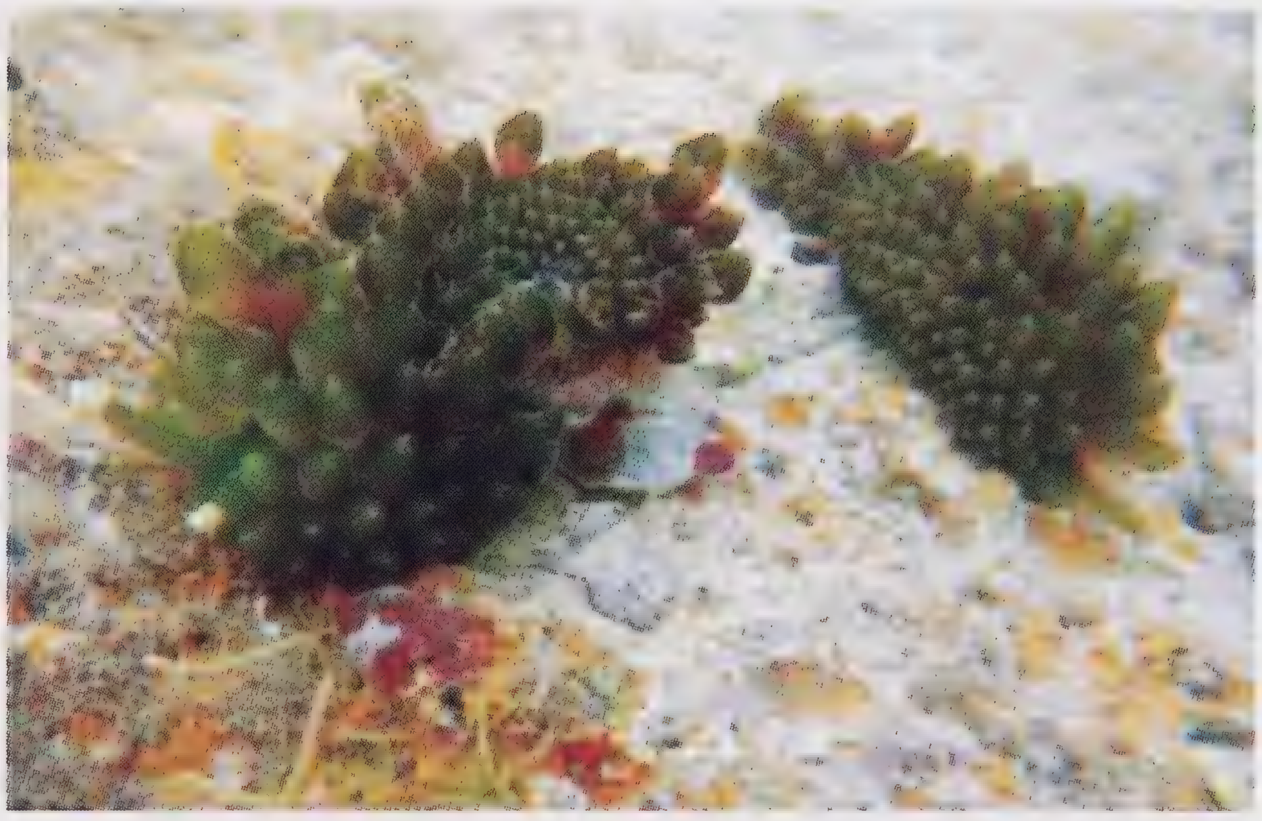

Fig. 2: *Stiliger smaragdinus* from Poshitra, Gulf of Kachchh, Gujarat

Colour of all specimens dark to light green. Cerata numerous, bubble-like, with pointed white tips. Both colour and bladder-shaped cerata perfectly match the host algae *C. racemosa* on which it was found almost exclusively. Cerata are autotomized when disturbed or while preserving. Rhinophores are rolled or folded, tips of the rhinophores white and blunt, which is diagnostic (Fig. 2). Pharynx and radula description match the one given by Jensen (1993). Pharynx large with finely striated dorsal septate muscle (Fig. 3). Radular teeth blade-shaped and denticulate

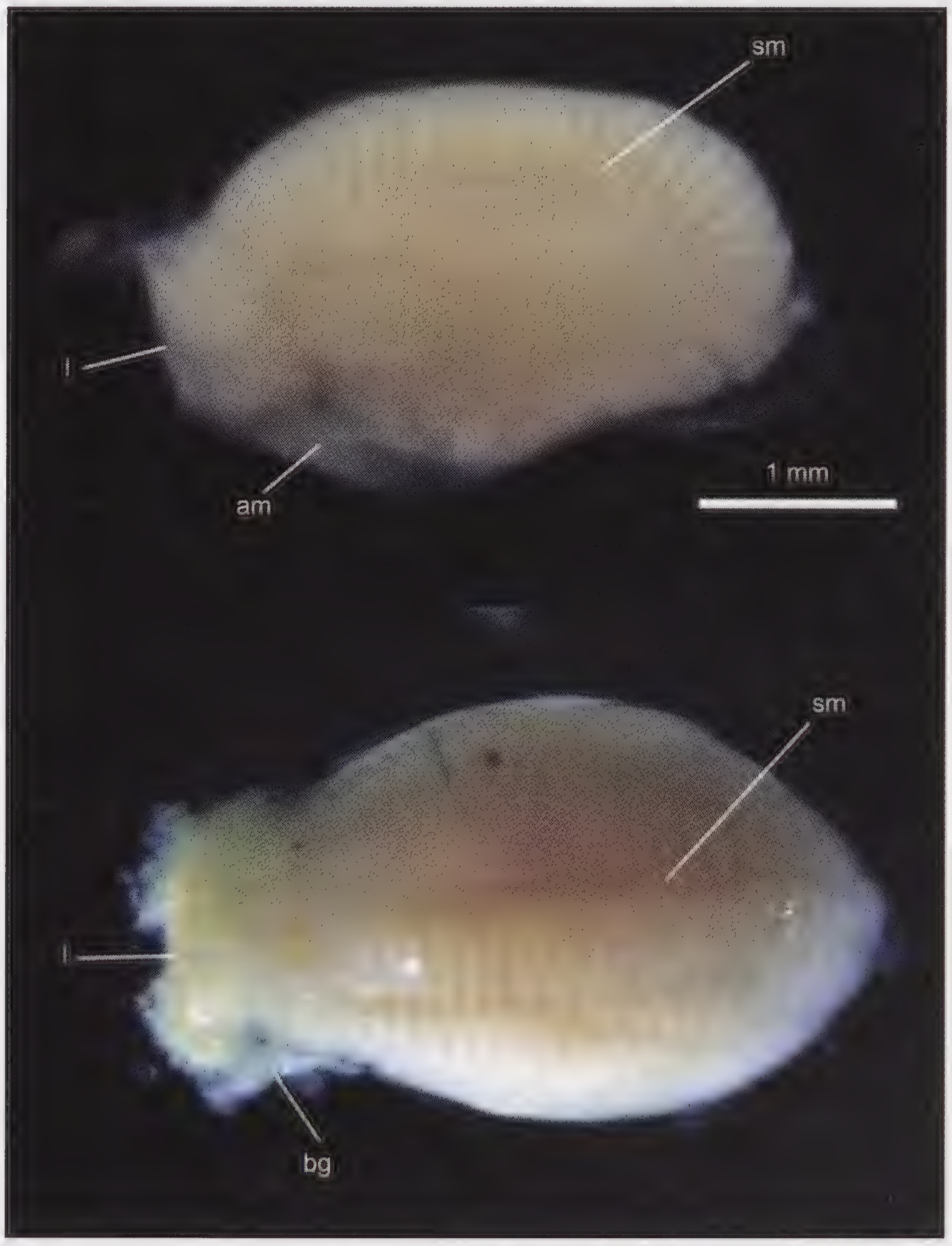

Fig. 3: Pharynx (sm = dorsal septate muscle; am = longitudinal ascus muscle; 1 = pharyngeal lips; bg = buccal gland)

Table 1: Checklist of previously recorded species of family Limapontiidae from India

Sr. No.	Scientific Name	Recorded by	Distribution
1	*Costasiella* cf. *kuroshimae* Ichikawa, 1993	Bhave and Apte 2011	Ratnagiri, Maharashtra
2	*Costasiella paweli* Ichikawa, 1993	Sreeraj *et al*. 2012	Andaman & Nicobar Islands
3	*Ercolania gopalai* (Rao, 1937)	Rao 1937; Sundaram *et al*. 1969	Mandapam (Palk Bay)
4	*Ercolania varians* (Eliot, 1904)	Sundaram *et al*. 1969	Mandapam (Palk Bay)
5	*Stiliger irregularis* Eliot, 1904	Sundaram *et al*. 1969	Mandapam (Palk Bay)
6	*Stiliger nigrovittatus* Rao & Rao, 1963	Rao and Rao 1963	Mandapam (Gulf of Mannar)
7	*Ercolania pica* (Annandale & Prashad, 1922)	Sewell and Annandale, 1922	Chilka Lake

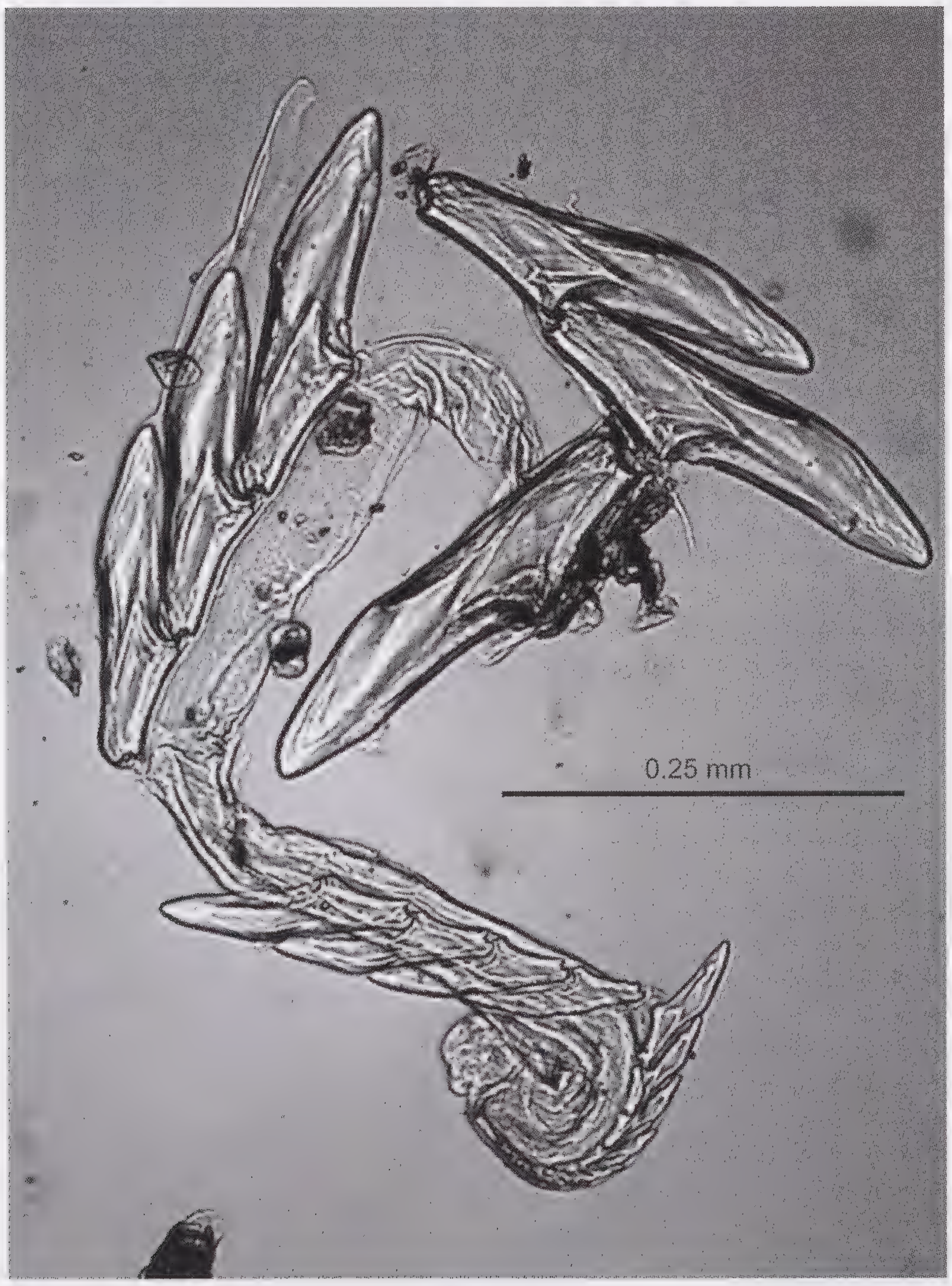

Fig. 4: Radular teeth of *S. smaragdinus*

(Fig. 4); ascending limb of radula with 5–6 teeth, descending limb with 21 teeth, bent over posteriorly in a 35 mm slug.

Discussion

The opisthobranch fauna of Gulf of Kachchh, Gujarat, India, is presently being studied comprehensively under AICOPTAX-Mollusca and other research programmes (Apte 2013; Apte *et al.*2010; Bhave and Apte 2013; Carmona *et al.* 2014; Parasharya and Patel 2014; Parasharya *et al.* 2014; Prasade *et al.* 2013, 2015; Subburaman *et al.* 2013).

The sacoglossan fauna of India is little studied and at present 41 species from 7 families have been reported. Of these, Family Limapontiidae is represented by 7 species (Table 1). Genus *Stiliger* is represented by two species from India namely *Stiliger irregularis* and *S. nigrovittatus*, reported from Gulf of Mannar. Both these species, however, have never been reported after the initial description. Marcus and Marcus (1956) provided a summary of 25 species of *Stiliger* found worldwide. However, only 12 species are currently considered valid (Bouchet and Gofas 2015). The present record adds one more species of genus *Stiliger* to Indian waters and extends the range of *S. smaragdinus* to India, far westwards from its present distribution. The nearest location from where it has been reported is Singapore. Though the reasons of its occurrence cannot be stated clearly, it may likely be an introduction through ballast, considering the large scale commercial shipping in the Gulf of Kachchh region, as well as the abundance of *Caulerpa racemosa* which is its host food plant.

Continued work on the opisthobranch fauna in India can further our understanding on these magnificent denizens of the oceans.

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21. SYNCHRONOUS SPAWNING OF THE SEA CUCUMBER *HOLOTHURIA* (*LESSONOTHURIA*) *PARDALIS* SELENKA, 1867 IN THE ANDAMAN ARCHIPELAGO, INDIA

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Holothurians (sea cucumbers) are known to broadcast-spawn thousands of gametes and produce large numbers of zygotes in order to achieve high fertilization success (Simon and Levitan 2011). The timing of these events is related to multiple factors: phase of the moon, temperature, salinity, tidal pressure changes, and nutrient/food availability (Morgan *et al*. 2011).

During a four-week expedition to North Andaman, we observed widespread synchronous spawning of the sea cucumber *Holothuria* (*Lessonothuria*) *pardalis* Selenka, 1867, on February 19, 2013, the fourth day after full moon, between 9:00 hrs and 10:00 hrs, at South Reef Island in Middle Andaman, India (12° 46′ 42.75″ N; 92° 39′ 15.25″ E). More than 100 individuals released gametes into the water column in short repeated bursts, creating a distinct cloud on the reefs between the depths of 12 and 20 m (Fig. 1).

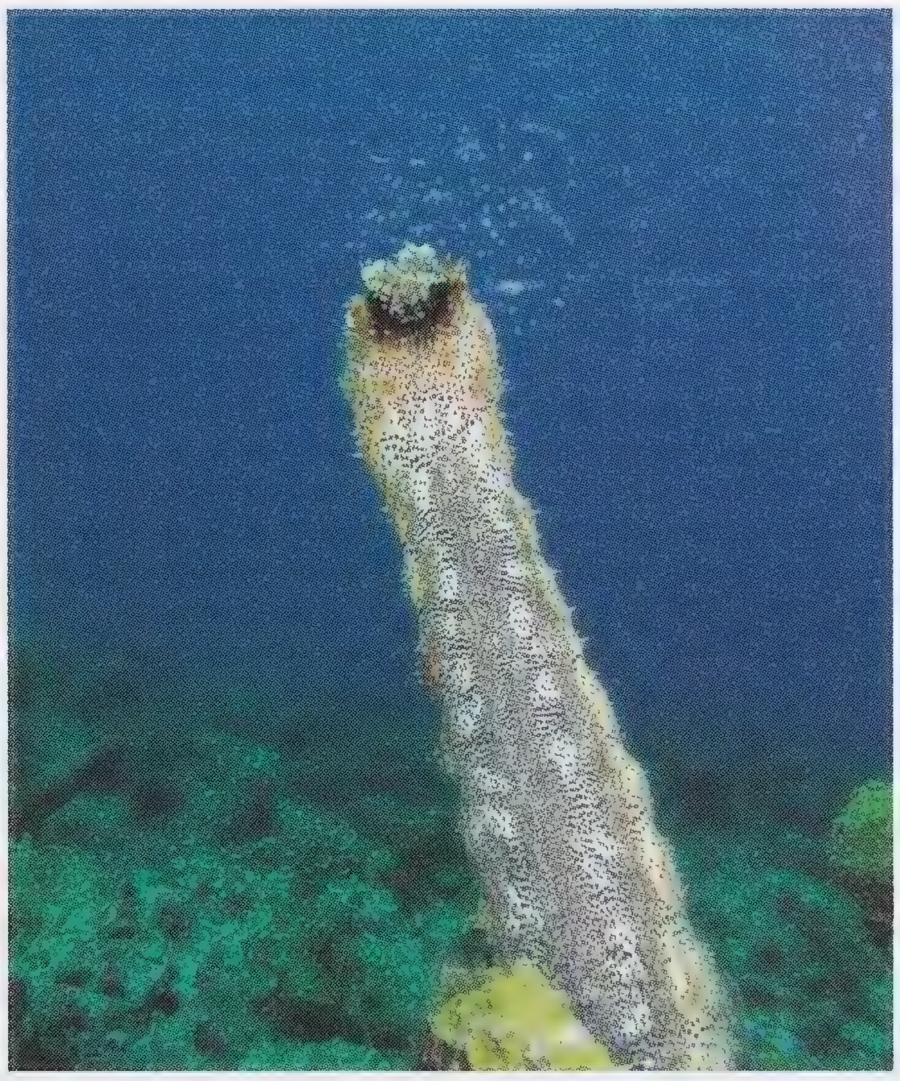

Fig. 1: Clouds of gametes being released by the Sea Cucumber *Holothuria* (*Lessonothuria*) *pardalis*

In India, information on sea cucumbers is limited to taxonomic descriptions and commercial importance of different species. They are protected under the Schedule I of the Indian Wildlife (Protection) Act, 1972. However, they are heavily exploited due to high demand for *Bêche-de-mer* from Southeast Asian countries (Advani *et al*. 2013). Though they are known for broadcast spawning, there is no record of a sea cucumber spawning event from Indian waters. This observation represents the first record of spawning in sea cucumber *Holothuria* (*Lessonothuria*) *paradalis*, and contributes to our understanding of reproductive patterns of the species. More information is needed about the spawning time of different species, for effective protection of sea cucumbers.

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22. *SCLERIA MULTILACUNOSA* T. KOYAMA AND *S. RUGOSA* R. BR. (CYPERACEAE): ADDITIONS TO THE FLORA OF KARNATAKA, INDIA

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Introduction

The genus *Scleria* Berg. is represented by about 200 species, some extending to subtropical and warm temperate regions (Prasad and Singh 2002). Many species of the genus *Scleria* are widely distributed in Asia, Australia, and also in Africa. In India, about 50 taxa are known, of which 27 taxa (23 species and 4 varieties) are reported from peninsular India, Andamans, and the rest of Maharashtra (Wadoodkhan *et al.* 2007). About 11 species and one variety are reported from Karnataka state (Prasad and Singh 2002).

During our floristic survey in Karnataka (2005–2010), we collected some specimens of *Scleria* Berg. from Belgaum and Karwar districts of Karnataka. After literature survey (Karthikeyan *et al.* 1989; Koyama 1985; Wadoodkhan 2015; Wadoodkhan *et al.* 2003, 2007) and critical analysis of specimens, the identity of the species was confirmed as *Scleria multilacunosa* T. Koyama and *S. rugosa* R.Br. A systematic scrutiny of literature (Prasad and Singh 2002; Sharma *et al.* 1984) revealed that these species have so far not been recorded from Karnataka state. Hence, they are reported here as new records for Karnataka. The voucher specimens of both the species are deposited in the Herbarium of the Botany Department, Shivaji University, Kolhapur (SUK).

Scleria **Berg.**

1) ***Scleria multilacunosa*** T. Koyama in Bull. Nat. Sci. Mus. 17(1): 71 f. 3: 1974; Koyama in Dassan. & Fosb. Rev. Hand. Fl. Ceylon 5: 361. 1985; W. Khan in J. Econ. Taxon. Bot. 27 (Suppl.) 1222. 2003; W. Khan in J. Econ. Taxon. Bot. 31 (3): 606. 2007. W. Khan in Cyperaceae WG, WC & Mahar. 361. 2015. Pl. XV. 80–81 & Pl. XVI. 82.

Tufted annual herbs with purplish fibrous roots. Culms 25–70 cm tall, 1.2–2.0 mm thick, sharply triquetrous, glabrous, smooth or weakly scabrid on angles, remotely 3 or 4 nodose. Basal sheaths 1–4 cm long, herbaceous or membranous, sharply triquetrous without wings, pale green and stained with purple. Leaves shorter than culm; blade linear, 15–30 cm long, 3–6 mm wide, flattened, tricostate, herbaceous, fresh green, glabrous, scabrous on margins, gradually tapering to acute apex; sheath 3–7 cm long, glabrous, greenish, sharply triquetrous, the angle scabrous, often narrowly winged; contraligule rounded-truncate, 0.4–0.7 mm long, ciliate with short rusty-brown hairs. Inflorescence with 2 to 4 partial panicles, the lowest one at a distance from the rest and on a long-exserted peduncle, the rest contiguous at the culm apex; partial panicles subspiciform, 1.0–2.5 cm long, 0.8–1.5 cm broad, the branches short, flattened with narrowly winged edges, bearing 3 to 5 pistillate spikelets and 1 to 3 staminate spikelets, those intermingle. Lowest leafy bract sheathed for 2 to 3 cm, blade 10–15 cm long, not surpassing the culm; other bract not sheathed, the blade of the second bract 3–6 cm long, longer than its subtending partial panicle, ciliate at base, third and fourth bracts much shorter; bracteoles setaceous. Staminate spikelets 3–4 mm long, lanceolate, short-peduncle. Pistillate spikelets 3–4.5 mm long, obdeltoid; glumes usually 3, ovate to lanceolate, 3.8–4.3 mm long, 1.2–2.3 mm wide, acuminate at apex, membranous, pale green and stained straw-brown, boat-shaped with prominent green keel ending in a straight cusp at apex. Nut globose, 2–3 mm long, 1.5–2.2 mm across, rounded at mucronate apex, the white-ceramic surface irregularly lacunose with many shallow depressions of varying shape and size; style 1 mm long, filiform; stigma 3, about 1 mm long. Disk 0.5–0.7 mm wide, deeply 3-lobed; lobes obovate-oblong, 0.8 mm long, 0.5 mm wide, subcoriaceous, yellowish, suddenly contracted at cuspidate apex.

Flowering & Fruiting: September–December.

Habitat: This species is found in wet grassland on the margins of bunds, wasteland, fields, margins of ponds and lakes.

Specimens Examined: INDIA: Karnataka: Belgaum district (Khanapur Tehsil, along Anmod-Nerse road), Coll.: A.N. Chandore 113 (SUK); Nipani, Coll.: A.N. Chandore 1921 (SUK); Maharashtra: Kolhapur district, Kagal, Coll.: W. Khan 4346; Shivaji University Campus, Coll.: W. Khan 4331; Aurangabad district, Maihsmal, Coll.: Naik 864; Nagpur district, Ambakhori, Coll.: W. Khan 4567.

Note: This species can easily be identified by its irregularly shallow lacunose nut with obovate apiculate disc lobes. Male spikelet 3–3.5 mm long; nuts 2–2.5 mm long.

2) ***Scleria rugosa*** R. Br. Prod. 240.1810; Govind. in J. Bombay Nat. Hist. Soc. 69 (1): 248. 1971; Koyama in Dassan. & Fosb. Rev. Hand. Fl. Ceylon 5: 363. 1985; W. Khan in J. Econ. Taxon. Bot. 27 (Suppl.) 1222. 2003; W. Khan *et al.* in J. Econ. Taxon. Bot. 31 (3): 606. 2007. W. Khan in Cyperaceae WG, WC & Mahar. 364. 2015. Pl. XVII. 87–88.

Densely tufted, annual herbs with purplish red fibrous roots. Culms 5–25 cm tall, 1–2 mm thick, acutely three angled, smooth, pubescent. Basal sheaths 1–5 cm long, straw brown in colour. Leaves narrowly linear, 3–18 cm long, 1–4 mm wide, flattened, greenish brown, densely hairy, gradually tapering to acute apex; sheath 1.5–3.5 cm long, glabrous, pubescent, triquetrous. Inflorescence axillary and terminal with 2 to 3 small panicles, each 1–2 cm long with a few clusters of spikelets, lateral panicles solitary or binate, more or less exserted peduncle; peduncles relatively stout; longest leafy bract suppressing whole inflorescence.Staminate spikelets one with a short peduncle, 2–2.5 mm long, lanceolate. Pistillate spikelets broadly obovate 3–4 mm long, glumes ovate, boat-shaped, 2.5–4.1 mm long, pale green, sometimes tinged red brown, acute tipped. Nut globular or broadly obovoid-globular, shorter than subtending glumes, 1.2–1.8 mm long, 1–1.4 mm broad, rounded at apiculate apex, white, glabrous, sometimes 4–6 faint brown lines on nut; style 1 mm long. Disk broad, shallowly 3-lobed; lobes semi-orbicular, densely glandular.

Flowering & Fruiting: October–December.

Habitat: Occasionally found in wet grassland and harvested rice fields in association with *Eleocharis atropurpurea* (Retz.) J. Presl & C. Presl, *Eriocaulon xeranthemum* Martius, *Rotala densiflora* (Roth ex Roemer et Schultes) Koehne.

Specimens Examined: INDIA: Karnataka: Along Kudra-Karwar road, 20.xi.2010, Coll.: A.N. Chandore 1915 (SUK); Maharashtra; Gondia district, Borkanhar, Coll.: W. Khan 4716, 4718, 4720, 4747.

Note: *Scleria rugosa* R. Br., can easily be identified with the help of its nut bearing spikelets 3–4 mm long; inflorescence of small axillary clusters with one terminal cluster; disc shallowly lobed; nuts smooth; plants densely hairy throughout.

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23. *ELEOCHARIS ATROPURPUREA* (RETZ.) J. PRESL & C. PRESL (CYPERACEAE) – A NEW RECORD FOR ANDAMAN & NICOBAR ISLANDS AND A NOTE ON ITS IDENTITY

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Introduction

Eleocharis atropurpurea (Retz.) J. Presl & C. Presl, commonly called Purple Spike-rush, belongs to the family Cyperaceae. *Eleocharis atropurpurea* is reported here for the first time from Andaman & Nicobar Islands, India. The present note provides a brief description with photographs and a note for easy identification.

During a floristic survey of the Andaman & Nicobar Islands in 2014, we collected some specimens of *Eleocharis* R. Br. After examination of relevant literature and critical analysis of nut morphology (Hooker 1893; Cook 1996; Prasad and Singh 2002), the identity of the species was determined as *Eleocharis atropurpurea* (Retz.) J. Presl & C. Presl. Scrutiny of the literature (Cook 1996; Pandey and Diwakar 2008; Vasudeva Rao 1986) revealed that this species has so far not been recorded from Andaman & Nicobar Islands. Hence, it is reported here as a new record.

Eleocharis atropurpurea (Retz.) J. Presl & C. Presl, Rel. Haenk. 1: 196. 1828; Clarke in Hook. *f.*, Fl. Brit. India 6: 627. 1894; T. Cooke, Fl. Pres. Bombay 3: 403. 1958 (Repr.); Karthik. *et al.*, Fl. Ind. Enum. Monocot. 48. 1989; C.D.K. Cook, Aquat. Wetl. Pl. India 127, f. 121 e-i. 1996. *Scirpus atropurpureus* Retz., Obs. 5: 14. 1789.

Annual herb. Stem slender, minutely angular, 4–12 cm long; up to 0.3 mm thick. Spikelets ovoid to oblong-ovoid 2–5 mm long, *c.* 2 mm broad. Glumes membranous, rather loosely arranged during fruiting, obtuse at apex. Perianth bristles 3–5, smooth or barbed, persistent, *c.* 0.7 mm long, white, shorter than or as long as nut. Ovary obovoid; style bifid for about half its length. Nut biconvex, obovate, 0.3–0.7 x 0.3–0.5 mm, chocolate brown to black when mature, with persistent minute discoid style base and perianth bristles.

Flowering and Fruiting: September–January.

Habitat: *Eleocharis atropurpurea* (Retz.) J. Presl & C. Presl grows in harvested fields and along the margin of ponds. It is seen in association with *Eriocaulon* sp., *Fimbristylis acuminata* Vahl, *Fimbristylis* sp., *Rotala* sp., and *Xyris indica* L.

Distribution in India: Assam, Delhi, Gujarat, Himachal Pradesh, Jammu & Kashmir, Kerala, Karnataka, Maharashtra, Madhya Pradesh, Punjab, Rajasthan, Tamil Nadu, Uttar Pradesh, West Bengal, and now Andaman & Nicobar Islands.

Specimens Examined: INDIA: Andaman & Nicobar Islands; along the roadside of Port Blair-Manglutant-Wandoor, 11.i.2014, Coll.: A.N. Chandore 1901 (SUK); Maharashtra; Ratnagiri district, along Pawas-Adiware road, 29.xi.2014, Coll: A.N. Chandore 1935 (SUK).

Note: *Eleocharis atropurpurea* (Retz.) J. Presl & C. Presl can be easily identified by its obovate black nut and white perianth bristles which are as long as or shorter than the nut. Several taxonomists have wrongly identified this species as *Eleocharis geniculata* (L.) Romer et Schulte in different herbaria. The species is similar to *E. geniculata* but differs in the following characters: 1) Perianth bristles white and as long as or shorter than nut (as against perianth bristles purplish-grey and longer than nut in *E. geniculata*), 2) All glumes fertile (as against lower two glumes sterile in *E. geniculata*), 3) Style base discoid (as against style base conical in *E. geniculata*), 4) Spikelets fuscous brown (as against spikelets straw coloured in *E. geniculata*) and 5) Culms generally less than 12 cm long (as against culms generally more than 12 cm long in *E. geniculata*).

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24. EFFECTIVE MODE OF POLLINATION IN RESPECT OF REPRODUCTIVE SUCCESS OF *JATROPHA CURCAS* L.

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Introduction

Jatropha curcas L. is a perennial shrub or small tree of family Euphorbiaceae, first described by the Swedish botanist Carl Linnaeus in 1753 (Kumar and Sharma 2008) It originated from South America, probably near Mexico, was introduced into Africa-Asia by Portuguese traders in the 16th century and later naturalized throughout the tropical, subtropical to temperate regions of the world, especially Africa and Asia (Ganesh Ram *et al.* 2008; Heller 1996; Sujatha and Prabakaran 1997; Openshaw 2000). In India, *J. curcas* is adapted to a wide range of climate and soils and is found in almost all the states. Since it is a drought-resistant oil yielding crop, it has drawn attention as a sustainable biofuel source for marginal degraded arid and semiarid areas (Francis *et al.* 2005; Jones and Miller 1992; Martin and Mayeux 1985). Though the mature seeds of *J. curcas* usually contain 25–40% crude oil to prepare biodiesel (Heller 1996), the low production per plant due to lack of sufficient fruit set (Fairless 2007) is a problem. Though some work on pollination ecology and breeding system of *Jatropha curcas* has been done, literature on effective mode of pollination is still meagre (Abdelgadir *et al.* 2009; Bhattacharya *et al.* 2005; Diwakar *et al.* 2010; Dhillon *et al.* 2006; Kaur *et al.* 2011; Solomon Raju and Ezradanam 2002; Yang *et al.* 2007). Pollination is a significant requirement of any crop plant for effective fruit and seed production, and its quality and quantity are useful in formulating strategies to enhance yield. Therefore, different pollination experiments were carried out in the present study on *Jatropha curcas* to deduce successful pollination mechanism.

Material and Methods

Study site

The experiments were carried out on 8–10 year old plants, which were raised at the CSIR-National Botanical Research Institute (26° 50′ N, 80° 54′ E; 123 m above msl), Lucknow, India, from seeds collected from diverse geographical regions of India.

Pollination experiments

To determine an effective pollination system and the pollinator's role in *J. curcas*, four pollination experiments were carried out in the field. For each of these four treatments, 50 randomly selected inflorescences from each of 10 randomly selected plants with sufficient male and female flower buds were taken, tagged, and subjected to the following pollination treatments:

Exclusion of all types of insects

Male and female flower buds were identified, counted in each inflorescence, and covered with muslin cloth bags and sealed to exclude pollinators/insects. Only wind and dust could enter.

Exclusion of large insects only

After identification and counting of male and female floral buds, each inflorescence was bagged with net cloth to exclude large insects only.

Manual pollination with the pollen of same inflorescence

After identification and counting of male and female floral buds, each inflorescence was bagged. Every bagged inflorescence was periodically opened and checked for opening of male and female flowers, and if so, pollen of freshly dehisced male flowers was transferred to the receptive stigmas with a fine brush and the inflorescence was rebagged. Stigma receptivity was confirmed at anthesis by the Benzidine test (Galen *et al.* 1985).

Open pollination exposed to all types of insects

After identification and counting of male and female floral buds, the inflorescences were tagged and exposed to all types of insects.

All the experiments were conducted from pre-anthesis to fruit initiation. Bags were removed when flowers withered and fruits initiated. The number of fruit sets was counted against the number of female flowers and the mean of the results was represented in percent as reproductive success for each pollination treatment.

Results and Discussion

Bagging with muslin cloth checked pollen transfer by small insects and honey bees. However, out of an average of 74.09 female flowers, none resulted in fruit, which determined pollination failure in the absence of any insect pollen vector (Table 1). Owing to large and sticky pollen

Table 1: Experiments conducted to deduce successful pollination system in *Jatropha curcas* (average data based on 50 inflorescences for each experiment)

Sl. No.	Type of pollination experiment	Avg. no. of male flowers per inflorescence	Avg. no. of female flowers per inflorescence	Avg. no. of female: male per inflorescence	Avg. no. of fruit initiated per inflorescence	Avg. Reproductive success % per inflorescence
1	Exclusion of all types of insects	74.09±24.66	4.54±2.34	1:16.30±9.09	Nil	Nil
2	Exclusion of large insects only	107.75±25.53	7.00±2.58	1:16.32±3.42	5.25±0.96	79.58±16.69
3	Manual pollination with the pollen of the same inflorescence	78.75±15.92	6.00±0.82	1:13.13±1.54	4.00±2.16	65.83±29.86
4	Emasculated inflorescence exposed to all types of insects	84.14±4.63	4.57±1.90	1:21.63±10.38	4.00±1.41	90.00±12.58

grains, their transportation via wind was restricted within the inflorescence. Bagging with net cloth totally excluded visits of large insects. In this experiment, pollen transportation to the stigma could be possible through small insects only, that showed 79% reproductive success (Table 1). Manual pollination with the pollen from the same inflorescence resulted in geitonogamy, which showed 65.83% reproductive success (Table 1). The inflorescence exposed to all types of insects had no pollen barrier. However, female flowers were free to receive pollen load through all types of pollen vectors. In this experiment, only geitonogamy, i.e. pollen transfer from the same inflorescence or different inflorescence of the same plant, and xenogamy, i.e. pollen transfer from different plant, might be possible via all types of pollinators. In this experiment, the plant showed 90% reproductive success through geitonogamy +xenogamy (Table 1).

Though flowers of *Jatropha curcas* are unattractive, they are good sources of pollen and nectar as reward. Due to the presence of conspicuous nectaries in both male and female flowers, nectar was easily available to various kinds of visitors. However, only bees identified as *Apis dorsata*, *A. mellifera*, and *A. cerana* were observed as potential pollinators. The flowers are well-adapted to bee pollination, as the hairy thorax of bees is a suitable adhering surface during nectar sucking activity (Faegri and van der Pijl 1970; Michener 2007). Though a few ants, flies, beetles and bugs were frequently seen visiting the flowers, they mainly foraged on the reproductive parts and accidentally participated in xenogamy and geitonogamy. However, ants were confined to the same plant, thus effecting only geitonogamy. Insect visitation peak hours were recorded between 09:00 hours and 14:00 hours, only on sunny days.

Jatropha curcas is a monoic plant, with unisexual male and female flowers produced in the same inflorescence. Usually the flower showed protandry, i.e. male flowers open first in an inflorescence and are relatively more numerous than female flowers (Table 1), but on a given day only a few male flowers bloomed per inflorescence. However, non-synchronous male and female flowering, and absence of mass flowering per plant had provided fewer open female flowers to the pollinators for pollen transfer. Though the study revealed up to 90% reproductive success in terms of fruit set, seed yield was restricted due to smaller number of female flower formation (Table 1). In addition, owing to large and sticky pollen grains, pollen transportation via wind is not possible even within an inflorescence, which is also reported by Chang-Wei *et al.* (2007). Large pollen grains of *J. curcas* with many verrucae on their exine as adhesive are suitable for insect pollinators. Though manual geitonogamy, i.e. pollination with the pollen of the same inflorescence, had also resulted in fruit formation, natural geitonogamy without the interaction of any type of insect/pollinator is not possible to set the fruit, as observed in this experiment that also ruled out the possibility of wind pollination in *J. curcas*. Higher percentage of reproductive success was observed in the inflorescences which were open to all types of visitors. However, it is confirmed that the plant relies strongly on entomophilous pollination, even to facilitate in-crossing. In the present study, most of the test plants of *J. curcas* indicated temporal dioecism because of protandry, but on a given day only a few freshly opened male flowers were present to attract visitors and facilitate geitonogamy. Within the inflorescence female counts were relatively very low when male flowering reached its peak, but due to pollen loss caused by regular visits of foraging beetles and ants and low pollen quality, female flowers of *J. curcas* still require mass male flowering along with adequate reliable pollinator activity to facilitate entomophilous pollination for good reproductive output, which could not be seen during the study. This hampered fruit formation.

Conclusion

It is obvious that biotic pollinator interaction is essential to facilitate pollination in *Jatropha curcas* as geitonogamous + xenogamous pollination via all types of insect pollinators is the best mode of breeding for good reproductive output. Honey bees identified as *Apis dorsata*, *A. mellifera* and *A. cerana* were observed to be the most suitable insect pollinators during the study. Such results may be helpful in formulating the strategies for breeding and conservation programmes of *J. curcas* by improving reproductive output.

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CONTENTS

EDITORIAL 53

MAPPING THE POTENTIAL DISTRIBUTION OF THE CRITICALLY ENDANGERED FOREST OWLET *HETEROGLAUX BLEWITTI* IN INDIA
Girish Jathar, Dharmaraj Patil, Mohit Kalra, Thilina de Silva, A. Townsend Peterson, Mohammed Irfan-Ullah, Asad R. Rahmani, Prachi Mehta and Jayant Kulkarni 55

DISTRIBUTION, ABUNDANCE, AND HABITAT SIGNATURE OF THE INDIAN GIANT FLYING SQUIRREL *PETAURISTA PHILIPPENSIS* (ELLIOT 1839) IN THE WESTERN GHATS, INDIA
Santhanakrishnan Babu, Honnavalli Nagaraj Kumara and Eluvathingal Antony Jayson 65

DIATOMS IN SUB-SURFACE SEDIMENT CORES FROM MANGROVE FOREST FLOORS OF DELTAIC ISLANDS IN SUNDARBANS, INDIA
Manjushree Mandal, Biswajit Biswas, Sanoyaz Sekh and Neera Sen Sarkar 72

NEW DESCRIPTION 83

REVIEWS 86

MISCELLANEOUS NOTES 88

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